LEEDS PHILOSOPHICAL
AND LITERARY SOCIETY.

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LVII. FEBRUARY 12, 1897. No. 4

A. A. Common, LL.D., F.R.S., President, in the Chair.

George Banks, 4 John Street, Bedford Row, W.C. ;
John Charles Clancey, F.R.G.S., F.S.I., 7 Grafton Square, Clapham Common, S.W. ;
William Fraser Doak, M.A., *Nautical Almanac* Office, 3 Verulam Buildings, Gray's Inn, W.C. ;
Rev. Edward Spry Leverton, M.A., School House, Kirkham, Lancashire ;
Ernest Frederick John Love, M.A., Lecturer in Physics in the University of Melbourne, Australia ;
William Arthur Smith, 78 Hagley Road, Edgbaston, and 94 Charlotte Street, Birmingham ; and
Edward Weldon, 10 Morden Road, Blackheath, S.E.,

were balloted for and duly elected Fellows of the Society.

The following Candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended :—

John Franklin-Adams, Wimbledon (proposed by L. Becker) ;
Rev. Sherrard Beaumont Burnaby, M.A., The Vicarage, Hampstead, N.W. (proposed by B. Woodd Smith) ;
John Sisson Slater, M.A., LL.D., Barrister-at-Law, 1 Garden Court, Temple, E.C., and Seafield House, Lytham (proposed by Sir R. S. Ball) ; and
Rev. John Spence, Minister of Chelsea Chapel, and 27 Walpole Street, Chelsea, S.W. (proposed by W. Willett).

Report of the Council to the Seventy-seventh Annual General Meeting of the Society.

The following table shows the progress and present state of the Society :—

	Compounders	Annual Subscribers	Total Fellows	Associates	Patron	Grand Total
December 31, 1895	245	391	636	46	1	683
Since elected	+6	+27	...	...	...	...
Deceased	...	−12	...	−6	...	...
Resigned	...	−12	...	...	...	...
Removals	+2	− 2	...	...	...	...
Expelled	...	− 1	...	...	...	...
December 31, 1896	253	391	644	40	1	685

Mr. Knobel's Account as Treasurer of the Royal

RECEIPTS.

	£	s.	d.	£	s.	d.
Balances, 1896 January 1:—						
At Bankers', as per Pass Book	286	12	10			
Outstanding Cheques	24	6	6			
In hand of Assistant Secretary on account of Turnor and Horrox Fund	14	8	4			
In hand of Assistant Secretary on Petty Cash Account	3	3	0			
In hand of Assistant Secretary on Account of Sales of Photographs, 1895	20	11	0			
				349	1	8
Dividends on £13,200 Consols, 2¾ per cent. ...	350	18	4			
„ on £900 New 2½-per-cent. Stock ...	21	15	0			
„ on £1,250 Metropolitan 3-per-cent. Stock	36	5	0			
				408	18	4
Received on account of Subscriptions:—						
Arrears	157	10	0			
Annual Contributions for 1896	604	16	0			
„ „ 1897	2	2	0			
Admission Fees	75	12	0			
First Contributions	48	6	0			
				888	6	0
Composition Fees				168	0	0
Sales of Publications:—						
At Williams and Norgate's, 1895	20	13	8			
At Society's Rooms, 1896	37	7	6			
Sale of Photographs, 1896	66	0	6			
				124	1	8
Income Tax refunded by Commissioners of Inland Revenue				14	1	8

Audited and found correct, 1897 January 6.

C. THWAITES,
DAVID SMART,
A. C. D. CROMMELIN.

£1,952 9 4

Astronomical Society, from 1896 *January* 1 *to December* 31.

EXPENDITURE.

	£	s.	d.	£	s.	d.
Assistant Secretary: Salary	250	0	0			
,, ,, for assistance in editing Society's Publications ...	50	0	0			
,, ,, for work in preparation of General Index	60	0	0			
				360	0	0
House Duty	2	12	6			
Fire Insurance	7	16	6			
				10	9	0
Printing, &c., *Monthly Notices*	326	10	9			
,, *General Index*	140	19	0			
,, *Memoirs*, vol. li.	223	8	0			
,, Miscellaneous	42	6	6			
Woodbury type Plates	10	9	0			
Lithography and Engraving	14	15	0			
				758	8	3
Reproduction of Photographs				65	18	11
Turnor and Horrox Fund: Purchases for Library	19	15	3			
Binding Books in Library	37	18	6			
				57	13	9
Cœlostat for Eclipse Observation				100	0	0
Clerk's Wages	52	0	0			
Postage and Telegrams	74	7	0			
Carriage of Parcels	2	14	3			
Stationery and Office Expenses	5	17	10			
				134	19	1
Expenses of Meetings	20	0	0			
Lantern Expenses	15	0	3			
				35	0	3
House Expenses	65	3	1			
Coals and Gas	39	0	3			
Electric Light Expenses	13	16	4			
Time Signal	5	0	0			
Sundry Fittings and Repairs	4	16	1			
Sundries	5	12	4			
				133	8	1
Decorating Rooms, balance of Trollope's Account	76	0	0			
Blinds on Staircase	7	1	6			
				83	1	6
Lee and Janson Fund Grants				11	10	0
Deductions on Cheques, &c.				0	3	0
Balances, 1896 December 31:—						
At Bankers', as per Pass Book	186	12	1			
In hand of Assistant Secretary on account of Turnor and Horrox Fund	14	13	1			
In hand of Assistant Secretary on Petty Cash Account	0	12	4			
				201	17	6
				£1,952	9	4

Report of the Auditors.

We have examined the Treasurer's accounts for the year 1896, and have found and certified the same to be correct. The cash in hand on 1896 December 31, including the balance at the bankers', &c., amounted to £201 17*s.* 6*d.*

The funded property of the Society is the same as at the end of the previous year.

The books, instruments, and other effects in the possession of the Society have been examined, and they appear to be in a satisfactory condition.

We have laid on the table a list of the names of those Fellows who are in arrear for sums due at the last Annual General Meeting of the Society, with the amount due against each Fellow's name.

We consider that the amount for which the Society's property is insured is too small to cover the value of the library, instruments, &c., and suggest that the insurance be increased.

(Signed) DAVID SMART,
ANDREW C. D. CROMMELIN,
C. THWAITES.

1897 *January* 8.

Trust Funds.

The Turnor Fund: A sum of £450 2¾-per-cent. Consols, the interest to be used in the purchase of books for the Library.

The Horrox Memorial Fund: A sum of £100 2¾-per-cent. Consols, the interest to be used in the purchase of books for the Library.

The Lee and Janson Fund: A sum of £323 16*s.* 6*d.* 2¾-per-cent. Consols, the interest to be given by the Council to the widow or orphan of any deceased Fellow or Associate of the Society who may stand in need of it.

The Hannah Jackson (*née Gwilt*) *Fund*: A sum of £300 2¾-per-cent. Consols, the interest to be given in Medals or other awards, in accordance with the terms of the Trust.

Assets and Present Property of the Society, 1897 January 1.

	£	s.	d.	£	s.	d.
Balances, 1896 December 31:—						
At Bankers'	186	12	1			
In hand of Assistant Secretary on account of Turnor and Horrox Fund	14	13	1			
In hand of Assistant Secretary on Petty Cash Account	0	12	4			
				201	17	6
Due on account of Subscriptions:—						
4 Contributions of 4 years' standing	33	12	0			
9 „ 3 „	56	14	0			
35 „ 2 „	147	0	0			
56 „ 1 „	117	12	0			
1 Admission Fee and First Contribution ...	3	3	0			
	358	1	0			
Less 1 Contribution for 1897 paid in advance	2	2	0			
				355	19	0
Due from Messrs. Williams and Norgate for sales of Publications during 1896				34	5	7

£13,200 $2\frac{3}{4}$-per-cent. Consols, including the Lee and Janson Fund, the Turnor and Horrox Fund, and the Jackson-Gwilt Fund.

£900 New $2\frac{1}{2}$-per-cent. Consols.

£1,250 Metropolitan 3-per-cent. Stock.

Astronomical and other Manuscripts, Books, Prints, and Instruments.

Furniture, &c.

Stock of Publications of the Society.

Stock in hand of volumes of the *Memoirs*:—

Vol.	At Society's Rooms	At Williams & Norgate's	Vol.	At Society's Rooms	At Williams & Norgate's
I. Part 1	7	...	XXX.	153	...
I. Part 2	42	...	XXXI.	136	...
II. Part 1	51	3	XXXII.	148	...
II. Part 2	17	3	XXXIII.	157	...
III. Part 1	65	1	XXXIV.	159	1
III. Part 2	83	1	XXXV.	105	2
IV. Part 1	78	3	XXXVI.	188	8
IV. Part 2	90	3	XXXVII. Part 1	334	7
V.	101	3	XXXVII. Part 2	279	8
VI.	119	6	XXXVIII.	264	1
VII.	141	3	XXXIX. Part 1	230	3
VIII.	125	3	XXXIX. Part 2	235	3
IX.	132	3	XL.	250	1
X.	144	...	XLI.	398	...
XI.	151	...	XLII.	226	3
XII.	157	...	XLIII.	227	...
XIII.	155	...	XLIV.	207	1
XIV.	363	...	XLV.	240	...
XV.	136	...	XLVI.	220	1
XVI.	161	1	XLVII. Part 1	3	...
XVII.	145	1	XLVII. Part 2	18	...
XVIII.	137	1	XLVII. Part 3	2	...
XIX.	147	...	XLVII. Part 4	10	...
XX.	136	1	XLVII. Part 5	8	...
XXI. Part 1	310	...	XLVII. Part 6	9	...
XXI. Part 2	98	...	XLVII.	194	1
XXI. 1 & 2 (together)	58	...	XLVIII. Pt. 1	243	...
XXII.	160	1	XLVIII. Pt. 2	237	1
XXIII.	144	...	XLIX. Part 1	381	1
XXIV.	151	1	XLIX. Part 2	263	...
XXV.	161	...	L.	258	1
XXVI.	167	1	LI.	325	1
XXVII.	419	1	Index to *Memoirs*	624	3
XXVIII.	378	...			
XXIX.	400	...			

Stock in hand of volumes of the *Monthly Notices*:—

Vol.	At Society's Rooms	At Williams & Norgate's	Vol.	At Society's Rooms	At Williams & Norgate's
I.	55	...	XXX.	63	2
II.	59	...	XXXI.	91	...
III.	...	...	XXXII.	109	5
IV.	...	...	XXXIII.	91	...
V.	...	...	XXXIV.	68	1
VI.	43	...	XXXV.	52	...
VII.	2	...	XXXVI.	26	1
VIII.	153	2	XXXVII.	33	3
IX.	24	3	XXXVIII.	96	2
X.	172	1	XXXIX.	93	...
XI.	184	...	XL.	105	3
XII.	106	2	XLI.	105	5
XIII.	177	2	XLII.	114	1
XIV.	176	3	XLIII.	111	2
XV.	168	2	XLIV.	114	2
XVI.	154	1	XLV.	115	1
XVII.	167	1	XLVI.	111	...
XVIII.	242	...	XLVII.	128	2
XIX.	52	...	XLVIII.	120	1
XX.	31	...	XLIX.	113	8
XXI.	16	...	L.	115	10
XXII.	30	...	LI.	116	8
XXIII.	17	...	LII.	116	12
XXIV.	22	...	LIII.	117	15
XXV.	13	...	LIV.	117	17
XXVI.	9	1	LV.	131	3
XXVII.	3	...	LVI.	124	7
XXVIII.	70	...	1st Index ...	550	5
XXIX.	51	...	2nd ,, ...	850	2
LIBRARY CATALOGUE				549	2

In addition to the above volumes of the *Monthly Notices*, the Society has a considerable stock of separate numbers of nearly all the volumes. With the exception, however, of Vols. XXXVI. to LVI., no complete volumes can be formed from the separate numbers in stock.

Instruments belonging to the Society.

A brief description of the chief instruments and other particulars relating to them will be found in *Monthly Notices*, vol. xxxvi. p. 126.

No. 1. The *Harrison* clock.
„ 2. The *Owen* portable circles, by Jones.
„ 3. The *Beaufoy* circle.
„ 4. The *Beaufoy* transit instrument.
„ 5. The *Herschel* 7-foot telescope.
„ 6. The *Greig* universal instrument, by Reichenbach and Ertel. The transit telescope, by Utzschneider and Fraunhofer, of Munich.
„ 7. The *Smeaton* equatorial.
„ 8. The *Cavendish* apparatus.
„ 9. The 7-foot Gregorian telescope (late Mr. Shearman's).
„ 10. The variation transit instrument (late Mr. Shearman's).
„ 11. The universal quadrat, by Abraham Sharp.
„ 12. The *Fuller* theodolite.
„ 13. The standard scale, by Troughton and Simms.
„ 14. The *Beaufoy* clock, No. 1.
„ 15. The *Beaufoy* clock, No. 2.
„ 16. The *Wollaston* telescope.
„ 17. The *Lee* circle.
„ 18. The *Sharpe* reflecting circle.
„ 19. The *Brisbane* circle.
„ 20. The *Baker* universal equatorial.
„ 21. The *Reade* transit.
„ 22. The *Matthew* equatorial, by Cooke.
„ 23. The *Matthew* transit instrument.
„ 24. The *South* transit instrument.
„ 25. A sextant, by Bird (formerly belonging to Captain Cook).
„ 26. A globe showing the precession of the equinoxes.
The *Sheepshanks* collection :—
„ 27. (1) 30-inch transit instrument, by Simms, with level and two iron stands.
„ 28. (2) 6-inch transit theodolite, with circles divided on silver; reading microscopes, both for altitude and azimuth; cross and siding levels; magnetic needle; plumb-line; portable clamping foot and tripod stand.

No. 29. (3) Equatorial stand and clock movement for $4\frac{6}{10}$-inch telescope (telescope lost); double-image micrometer; two wire micrometers; object-glass micrometer.

„ 30. (4) $3\frac{1}{4}$-inch achromatic telescope, with equatorial stand; double-image micrometer; one terrestrial and three astronomical eyepieces.

„ 31. (5) $2\frac{3}{4}$-inch achromatic telescope, with stand; one terrestrial and three astronomical eyepieces.

„ 33. (7) 2-foot navy telescope.

„ 34. (8) Transit instrument of 45 inches focal length, with iron stand and also Y's for fixing to stone piers; two axis levels.

„ 35. (9) Repeating theodolite, by Ertel, with folding tripod stand.

„ 36. (10) 8-inch pillar sextant, by Troughton, divided on platinum, with counterpoise stand and artificial horizon.

„ 37. (11) Portable zenith telescope and stand, $2\frac{3}{4}$-inch aperture and 26 inches focal length; 10-inch horizontal circle and 8-inch vertical circle, reading to 10″ by two verniers to each circle.

„ 38. (12) 18-inch Borda repeating circle, by Troughton, $2\frac{1}{8}$-inch aperture and 24 inches focal length; the circles divided on silver, the horizontal circle being read by four verniers, and the vertical circle by three verniers, each to 10″.

„ 39. (13) 8-inch vertical repeating circle, with diagonal telescope, by Troughton and Simms; circle divided on silver, reading to 10″; a 5-inch circle at eye-end, reading to single minutes; horizontal circle 9 inches diameter in brass to single minutes.

„ 40. (14) A set of surveying instruments, consisting of a 12-inch theodolite for horizontal angles only, reading to 10″; two sets of adjusting plates; tripod stand with enclosed telescope; heavy stand for theodolite; Y-piece of level; two large and three small ground-glass bubbles divided; level collimator, object-glass $1\frac{2}{3}$-inch diameter and 16 inches focal length; micrometer eyepiece, comb, and wires; mercury bottle and trough.

„ 41. (15) Level collimator, with object-glass $1\frac{4}{5}$-inch diameter and 16 inches focal length; stand, rider-level, and fittings.

„ 42. (16) 10-inch reflecting circle by Troughton, reading by three verniers to 20″; counterpoise stand; artificial horizon, with mercury; two tripod stands.

„ 43. (17) Hassler's reflecting circle, by Troughton, with counterpoise stand.

„ 44. (18) 6-inch reflecting and repeating circle, by Troughton and Simms, contained in three boxes, two of which form stands. Circle divided on silver, reading to single minutes; two inside arcs divided to single degrees, 150 degrees on each side; artificial horizon and mercury.

No. 45. (19) 5-inch reflecting and repeating circle, by Lenoir, of Paris.
„ 46. (20) Reflecting circle, by Jecker, of Paris, 11 inches in diameter, with one vernier reading to 15″.
„ 47. (21) Box sextant; reflecting plane and level.
„ 48. (22) Prismatic compass, by Troughton and Simms.
„ 49. (23) Mountain barometer.
„ 50. (24) Prismatic compass, by Thomas Jones, mounted with a cylindrical lens.
„ 51. (25) Ordinary $4\frac{1}{2}$-inch compass with needle.
„ 52. (26) Dipping needle, by Robinson.
„ 53. (27) Compass needle, mounted for variation.
„ 54. (28) Magnetic intensity needle, by Meyerstein, of Göttingen; a strongly fitted brass box with heavy magnet; filar suspension.
„ 55. (29) Box of magnetic apparatus.
„ 56. (30) Hassler's reflecting circle, by Troughton; a $10\frac{1}{2}$-inch reflecting and repeating circle, with stand and counterpoise, divided on platinum with two movable and two fixed indices; four verniers reading to 10″.
„ 57. (31) Box sextant and glass plane artificial horizon, by Troughton and Simms.
„ 58. (32) Plane $2\frac{3}{8}$-inch speculum, artificial horizon and stand.
„ 59. (33) $2\frac{1}{2}$-inch circular level horizon, by Dollond.
„ 60. (34) Artificial horizon, roof, and trough; the trough $8\frac{1}{4}$ by $4\frac{1}{2}$ inches; tripod stand.
„ 61. (35) Set of drawing instruments, consisting of 6-inch circular protractor and common protractor, T-square; one beam compass.
„ 62. (36) A pantograph.
„ 63. (37) A noddy.
„ 64. (38) A small Galilean telescope with object-glass of rock crystal.
„ 65. (39) Five levels.
„ 66. (40) 18-inch celestial globe.
„ 67. (41) Varley stand for telescope.
„ 69. (43) Telescope, with object-glass of rock crystal.
„ 71. Portable altazimuth tripod.
„ 72. Four polarimeters.
„ 74. Registering spectroscope, with one large prism.
„ 76. Two five-prism direct-vision spectroscopes.
„ 78. $9\frac{1}{4}$-inch silvered-glass reflector and stand, by Browning.
„ 79. Spectroscope.
„ 80. A small box, containing three square-headed Nicol's prisms; two Babinet's compensators; two double-image prisms; three Savarts; one positive eyepiece, with Nicol's prism; one dark wedge.
„ 81. A back-staff, or Davis' quadrant.
„ 82. A nocturnal or star dial.

No. 83. An early non-achromatic telescope, of about 3 feet focal length in oak tube, by Samuel Scatliffe, London.
„ 84. A Hollis observing chair.
„ 85. Double-image micrometer, by Troughton and Simms.
„ 86. $4\frac{1}{2}$-inch Gregorian reflecting telescope, by Short, with altazimuth stand and 6-inch altitude and azimuth circles and two eyepieces.
„ 87. $3\frac{1}{4}$-inch Gregorian reflecting telescope with wooden tripod stand.
„ 88. Pendulum, with 5-foot brass suspension rod, working on knife-edges, by Thomas Jones.
„ 89. A Rhabdological Abacus. A contrivance invented by Mr. H. Goodwyn, consisting of a box filled with compartments, in which are square rods covered with numbers, which can be arranged so as to facilitate the labour of multiplying high numbers.
„ 90. An Arabic celestial globe of bronze, $5\frac{3}{4}$ inches in diameter.
„ 91. Astronomical time watch-case, by Professor Chevalier.
„ 92. 2-foot protractor, with two movable arms, and vernier.
„ 93. Beam compass, in box.
„ 94. 2-foot navigation scale.
„ 95. Stand for testing measures of length.
„ 96. Artificial planet and star, for testing the measurement of a fixed distance at different position-angles.
„ 97. 12-cell Leclanché battery.
„ 98. 2-foot 6-inch navy telescope, with object-glass $2\frac{1}{2}$ inches, by Cooke, with portable wooden tripod stand.
„ 99. 12-inch transit instrument, by Fayrer and Son, with level and portable stand.
„ 100. 9-inch transit instrument, with level and iron stand.
„ 101. Small equatorial sight instrument, by G. Adams, London.
„ 102. Sun-dial, by Troughton.
„ 103. Sun-dial, by Casella.
„ 104. Sun-dial.
„ 105. Box sextant, by Troughton and Simms.
„ 106. Prismatic compass, by Schmalcalder, London.
„ 107. Compass, by C. Earle, Melbourne.
„ 108. Prismatic compass, by Negretti and Zambra.
„ 109. Dipleidoscope, by E. Dent.
„ 110. Abney level, by Elliott.
„ 111. Pocket spectroscope, by Browning.
„ 112. Universal sun-dial.
„ 113. Double sextant, by Jones.
„ 114. Two models, illustrating the effects of circular motions.
„ 115. A cometarium.
„ 117. } Two old sun-dials.
„ 118. }
„ 119. Specimens of diffraction gratings, by Prof. W. A. Rogers.

No. 120. A 6-prism spectroscope, by Browning.
„ 121. Spitta's improved maximum and minimum thermometer.
„ 122. A 6-inch speculum, with flat; the speculum said to be by Sir W. Herschel, and re-figured by Sir J. Herschel.
„ 123. A 6-inch refracting telescope, by Grubb, with 3 eye-pieces.
„ 124. Position micrometer, by Cooke.
„ 125. A 6-inch refracting telescope, by Simms, with eyepieces and solar diagonal.
„ 126. $3\frac{1}{2}$-inch portable refracting telescope, by Tulley, with tripod stand.
„ 127. Globe representing the visible surface of the Moon, by John Russell, R.A. (1797).
„ 128. Bichromate battery and Ruhmkorff coil.
„ 129. Slater's improved armillary sphere.
„ 130. 10-inch brass pillar sextant, by Troughton.
„ 131. Double box sextant, by Cary.

Besides the above, there is the following apparatus available for eclipse work :—

4 Slits for spectroscope.
2 Abney lenses used in photographing the corona.
2 Dallmeyer negative enlarging lenses.
1 Cœlostat with 16-inch plane mirror.

The following instruments are lent, during the pleasure of the Council, to the undermentioned persons :—

No. 4. The *Beaufoy* transit instrument, to the Observatory, Kingston, Canada.
„ 16. The *Wollaston* telescope, to Mr. R. Inwards.
„ 22. The *Matthew* equatorial, to Mr. J. Brett.
„ 23. The *Matthew* transit, to Captain W. Noble.
„ 27. (1) 30-inch transit and stand, to Mr. B. T. Moore.
„ 28. (2) 6-inch theodolite and stand, to Dr. A. A. Common.
„ 29. (3) Equatorial mounting, clock, &c., to the Rev. C. D. P. Davies.
„ „ Wire micrometer (No. 1), to Mr. C. Thwaites.
„ 30. (4) $3\frac{1}{4}$-inch equatorial, to Mr. E. B. Powell.
„ 31. (5) $2\frac{3}{4}$-inch telescope and stand, to Mr. F. J. Wardale.
„ 47. (21) Box sextant and horizon, to Mr. C. H. Johns.
„ 50. (24) Prismatic compass, to Mr. Maxwell Hall.
„ 69. (43) Telescope with rock-crystal object glass, to Dr. W. Huggins.
„ 72. (*a*) Polarimeter, to Dr. A. M. W. Downing.
„ 72. (*c*) Polarimeter, to Professor C. M. Smith.
„ 78. $9\frac{1}{3}$-inch reflector and stand, to Mr. Maxwell Hall.
„ 85. Double image micrometer, to Mr. B. T. Moore.

No. 99. 12-inch transit with portable stand, to Mr. H. T. Vivian.
„ 119. Diffraction gratings, to Mr. B. T. Moore.
„ 120. 6-prism spectroscope, to Mr. C. Thwaites.
„ 123. 6-inch telescope, by Grubb (object-glass only) to Mr. W. E. Wilson.
„ 125. 6-inch refractor by Simms, to Dr. A. A. Common.
„ 126. $3\frac{1}{2}$-inch portable refractor, by Tulley, to Mr. H. Sadler.
„ 128. Bichromate battery and Ruhmkorff coil, to the Rev. W. J. B. Roome.

The Gold Medal.

The Council have awarded the Society's Gold Medal to Mr. E. E. Barnard, for his discovery of the fifth satellite of *Jupiter*, his celestial photographs, and other astronomical work. The President will lay before the Society the grounds upon which the award has been founded.

The Hannah Jackson (née Gwilt) Gift.

The Council have awarded this Gift, consisting of a bronze medal and the accumulated dividends of three years, to Mr. Lewis Swift, for his cometary discoveries and other astronomical work.

Publications of the Society.

A General Index to volumes xxx.–lii. of the *Monthly Notices* has been published during the past year, in continuation of the General Index to volumes i.–xxix., published in 1870.

Obituary.

The Council regret that they have to announce the loss by death of the following Fellows and Associates during the past year :—

Fellows :—G. P. Bidder.
Rev. Henry Collins.
T. G. E. Elger.
G. R. Farncombe.
A. H. Howe.
George Hunt.
J. H. Jones.
J. R. Jones.
Thomas Keig.
Rev. Thomas Mackereth.
S. H. Parkes.
Sir John Pender.
W. L. Sutton.
Sidney Waters.

Associates :—B. A. Gould.
Hugo Gyldén.
Adalbert Krueger.
Axel Möller.
H. A. Newton.
F. F. Tisserand.

[The names of Fellows who have died between December 31 and the date of the annual meeting are included in the above list, but omitted in the count given in the table at the commencement of the Report.]

George Parker Bidder was born 1836 August 18 in London. He was the eldest son of George Parker Bidder, C.E. (President 1860 and 1861), one of the leading engineers of the middle of the century, and known from boyhood for his powers of mental calculation. Mr. Bidder, the son, attained distinction in mathematics at the Universities, first of Edinburgh, and then of Cambridge (where he was scholar of Trinity College, and Seventh Wrangler in 1858) : he was called to the Bar at Lincoln's Inn in 1860, joining the Home Circuit. His success was very rapid, so that in 1874 he took silk, and for

the last fifteen years of his life had one of the largest practices at the Parliamentary Bar. The Forth Bridge Bills, the Tay Bridge Enquiry, and the Manchester Ship Canal Bills, are probably best known to the public among the more important cases which achieved his reputation. He was, perhaps, most sought after where it was necessary to meet a heavy array of expert evidence; this his naturally scientific mind and his mathematical training enabled him to dissect with a merciless thoroughness that discomposed all but the most candid and able witnesses. Without doubt he was greatly aided by the inheritance to some degree of the faculty of mental calculation; though by no means commensurate with that of his father, it was sufficiently above the average to give him a great advantage in tracing the various figures given in evidence to their natural, and often impossible, consequences. His mind was stored with formulæ and constants adapted to the rough estimation of quantities of all kinds, from the figures in the *Nautical Almanac* to those in a builder's estimate. The construction and testing of such formulæ, as also of purely numerical theorems, were among his favourite recreations.*

Mr. Bidder was elected Fellow of the Royal Astronomical Society on 1868 January 10, and was for many years a constant attendant at the meetings. He had a $7\frac{1}{2}$-inch refractor mounted for him by Browning, and for some ten years worked seriously at the measurement of double stars. For this purpose he invented a position micrometer (described in the *Monthly Notices*, vol. xxxiv. p. 394) in which he measured with the images of the illuminated wires, the actual wires not being seen by the observer. He always afterwards used this instrument, and maintained that his measurements showed a far higher degree of accuracy with it than was possible with the ordinary form.

He wrote more than once advocating the theory that the tail of a comet is an optical effect due to lenticular action of the cometary matter on the Sun's rays, a theory in which he found he had been anticipated by a writer early in the century (see *The Times*, 1874 July 24). He was Associate of the Institution of Civil Engineers (where he obtained the Manby Premium, in 1861, for a paper on "The National Defences"), and of the Surveyors' Institution. Mr. Bidder married, in 1860, Anna, daughter of Mr. J. R. McClean, M.P., F.R.S., President of the Institution of Civil Engineers for 1864–5, and Fellow of the Royal Astronomical Society (see Obituary, for 1873), and leaves three sons and four daughters. He resided at Ravensbury Park, Mitcham, and Queen Anne's Mansions, Westminster.

Among a very wide circle of acquaintances there were few that might not have been called friends. Personally he was

* A note by Mr. Bidder on the mental calculation of logarithms will be found in a paper by Dr. W. Pole, in *Minutes of Proceedings, Inst. C.E.*, vol. ciii. p. 250.

remarkable for his strength both of body and character, allowing himself neither to be checked nor daunted by any opposition but that of his own principles, which were high and unbending. Yet he was of a tender and loving nature, and singularly light-hearted.

He died at Queen Anne's Mansions on 1896 February 1, of a clot of blood in the heart, the effects of an accident three weeks previously. He died in full success and full vigour, suddenly and painlessly.

[For the above notice the Council is indebted to his son, Mr. George P. Bidder.]

The Rev. Henry Collins was born at Burslem, Staffordshire, 1830 February 16. He was vicar of Ellerton Priory, near Wheldrake, York, from 1870 June to 1888 December; and rector of Elvington, York, from the latter date till his death. He was of a nervous and retiring disposition, and devoted much time to reading. He married (1859 May 5) Mary Ann, daughter of the late Mr. William Wells, of Kenninghall, Norfolk, and leaves no issue. He died at Elvington Rectory on 1896 March 14. He was elected a Fellow of this Society on 1876 January 14.

Thomas Gwyn Empy Elger was born at Bedford in 1837, where the family had been established for several generations. His grandfather was Mayor of the town in 1802, and his father, an architect and builder, had three times filled that office. Thomas Elger was educated at the Bedford Grammar School, and afterwards went to University College, London, where he was a pupil of De Morgan. He adopted the profession of a civil engineer, and under Mr. (now Sir John) Fowler, he was engaged in several important works, including the Metropolitan Railway and the Severn Valley Railway. Afterwards he was engaged in surveys for railway construction in Holstein, until the work was put a stop to by the war with Prussia and Austria in 1864.

Having succeeded to his property, he relinquished the active pursuit of his profession, and devoted himself more fully to scientific studies. At an early age he had showed a strong taste for astronomy, and as a youth had constructed a telescope which served him many years later. He erected his first observatory in Caldwell Street, Bedford, where he settled with his mother. In 1880 he married, and removed to Kempston, near Bedford, where he set up an observatory in his garden, with a 4-inch refractor by Cooke, and an $8\frac{1}{2}$-inch reflector by Calver. About eight years ago he built a house in Shakespeare Road, Bedford, in which he lived till his death.

Mr. Elger's first communication to the Royal Astronomical Society, of which he was elected a Fellow on 1871 Feb. 10, was a brief note on the colours of the components of the double-star γ *Delphini*; and this was followed by observations of *Venus*, in 1873. He also gave in the *Monthly Notices* the results of a series of observations of *Saturn*, in 1887 and 1888, specially calling

attention to peculiar appearances in the crape ring, and to the varying form of the shadow of the ball upon the rings.

But it is as a careful and indefatigable selenographer that his name is best known, and for this work his artistic skill eminently qualified him. In 1878 he became a member of the Selenographical Society, a small association of observers devoted to the study of the Moon, which existed till 1882, and he contributed various papers on lunar details to its journal. He continued this work in his numerous communications to the Liverpool Astronomical Society (1882–89), and was one of the first members of the British Astronomical Association, founded in 1890. He was Director of the Lunar Section of this Association, and gave three excellent reports of the Section in 1891, 1893, and 1895, in which are digests of the work done by other observers as well as by himself. He gave results of his lunar observations in a series of articles in the *English Mechanic*, and from 1887 contributed every month to *The Observatory* a valuable chapter of selenographical notes. He was the author of the chapters on the Moon in Webb's *Celestial Objects for Common Telescopes*, and *Astronomy for Amateurs*, edited by Westwood Oliver. His most considerable work, *The Moon*, was published in 1895, and is a valuable original contribution to selenography, containing an excellent map of the Moon on a scale of 18 inches to the diameter. Most of his papers are illustrated by his own careful drawings.

Mr. Elger was an ardent archæologist, and had a fine collection of antiquities. He was one of the main supporters of the Bedford Library and the Literary Institute, and was the founder of the Bedfordshire Natural History Society and Field Club, afterwards united with the Library and Institute. His services were always at the disposal of his fellow townsmen : he was a member of numerous committees, by which his loss will be greatly felt, and, like his father and grandfather, he served as Mayor of Bedford.

He was seized with paralysis in December last, and remained in a very weak state till January 9, when he died, at the age of 59, leaving a widow and two young sons.

George Richard Farncombe, whose death occurred 1895 July 7, at Freiburg-im-Breisgau, was born at Birmingham, 1866 August 12. Being of a delicate constitution, he received a private education, and he subsequently graduated at Trinity College, Dublin (in 1884), receiving Respondent Honours. He then became articled to a firm of solicitors in Birmingham, filling up his leisure with those astronomical, meteorological, and geological studies which had early attracted him. In 1890 he came to London to prepare for his final examination in law, and threw himself heartily into the work of the numerous scientific societies of which he had long been a member. He joined and greatly enjoyed the London Geological Field Class, and in a short time Mr. Farncombe decided to relinquish the law and to devote himself entirely to geology. With this view he went to Edinburgh,

and studied for a year under Professor Geikie. Then he returned to Dublin, and worked with Professor Cole. Here his health broke down, and he was compelled to spend a winter at St. Moritz. With the return of strength he proceeded to Munich, Freiburg, Vienna, and Berlin, spending several months at each University. In 1894 September he attended the Geological Congress at Munich, and in the following November returned to Freiburg to work with Professor Steinmann. Here his knowledge and industry speedily attracted attention, and in 1895 May Mr. Farncombe was sent into Italy to undertake some survey work. There he unfortunately drank some contaminated water and contracted typhoid fever, which developed on his return, and to which he succumbed in the midst of apparent convalescence. His funeral was attended by the Rector, Senate, and Professors of the University, while every "corps" among the students sent a deputation consisting of the flag-bearer, sword-bearers, and six men. Mr. Farncombe's character was such as to secure him respect and affection wherever he went; while his great abilities, combined with a tireless industry, would have doubtless led him to a high position in his profession had his life been spared.

He was elected a Fellow of this Society on 1890 January 10.

Alexander Hamilton Howe was born at Hullerhurst, Stevenston, Ayrshire, in 1816. He was boarded in Saltcoats with Mr. Edward Gibb, parish schoolmaster of Ardrossan; next with the Rev. Mr. Roxburgh, Kilmaurs; was afterwards at Ayr Academy, Glasgow University, Edinburgh University, and finally at Paris. He was appointed to the East India Company's Civil Service; and for several years lived on the borders of Afghanistan. During the last war in that country he was attached to the reserve force. He was an excellent linguist, an enthusiastic student of astronomy and botany, and a frequent contributor to the press. In 1865 he published a book entitled, "A Theoretical Enquiry into the Physical Cause of Epidemic Diseases, accompanied with Tables," a copy of which is in the Society's library. It is devoted to proving that epidemics are caused by the effect of the Moon upon the Earth's atmosphere, and have an eighteen and a half years' period depending on the revolution of the Moon's nodes.

On his return from India he married Anne Forbes, daughter of the late Colonel Robertson, of Hallcraig, county Lanark, who survives him. He was greatly esteemed in the parish of Stevenston, where he passed the remainder of his life. He died on 1895 July 21, but the news of his death has only recently reached us.

He was elected a Fellow of this Society on 1883 January 12.

George Hunt was born at Liverpool in 1823, and, being the only survivor of four brothers, was naturally the object of great anxiety on the part of a delicate mother, who became later a confirmed invalid. After a few years at a preparatory school at Bootle, he attended the High School of the Mechanics' Institute at Liverpool, and finished his education with a private tutor. His mother's ill-health made his home life a quiet one. He took no part in active sports, and devoted himself to study. The awakening of his interest in the microscope and in astronomy was due to a neighbour, Mr. Gee. After the death of his mother he accompanied his father to Birmingham, where his uncles were engaged in ironworks and collieries. At one time they wished George Hunt to become a member of the business known as the Brades Works, at Oldbury, but after eighteen months' trial he found it so distasteful and the loss of time for his literary studies so trying that he determined to give up business. After his father's death, he spent most of his time with an uncle, who eventually made him his heir. It was then (1869) that he purchased the late Rev. W. R. Dawes's equatorial, which he erected first at Edgbaston and later at Dulwich, whither he removed three years after his marriage, in 1871. A retiring disposition prevented his taking a prominent place in the astronomical world, but his knowledge was very thorough and extensive. Among his papers are letters which show that others' estimate of his attainments far exceeded his own modest one. His illness was a short one, and his death sudden and unexpected from heart failure, after a slight attack of pneumonia, owing greatly to exhaustion from the excessive heat. He died on 1896 July 9, and was buried at Norwood. He was elected a Fellow on 1866 April 13, and in 1872 contributed to the Society a short paper "On the Identity of the Triple Star H I. 13."

John Harvey Jones was born on 1859 July 13, at Corsham, near Bath. He accompanied his father to Bristol a few years later, and assisted him in his business as a manufacturer of organs and other musical instruments. When very young he exhibited a great fondness for astronomy, and procured himself a telescope and some practical books on the science. He married in 1884 July and visited Australia, returning home in the following year and joining his father in business in Budge Street, Bristol. He first employed a $5\frac{1}{2}$-inch Gregorian telescope, but afterwards procured a $5\frac{1}{4}$-inch equatorial from Mr. Calver, which he subsequently replaced by a $8\frac{1}{2}$-inch altazimuth. He was elected a Fellow of the Royal Astronomical Society on 1888 December 14, and joined the British Astronomical Association at its formation. He became a member of the Lunar section of the latter, and furnished observations and drawings. His chief delight was in surveying the Moon and planets, and every clear night found him at his telescope, though he was not a regular contributor to the scientific journals. In 1893 he took up

meteorology, and furnished reports to the Meteorological Office for several years. He was a frequent contributor to the local newspapers, and supplied them with monthly remarks on the climatology of the district. Mr. Jones was an accomplished performer on several musical instruments, and was for some years organist at St. Nathaniel's Church, Bristol. He had also proved himself an excellent lecturer, and gave an impressive discourse on astronomy about a week before he died. Though his name was not widely known, he formed one of that numerous band of workers who love astronomy for its own sake, and who aim to contribute their little to the general progress of knowledge. A true friend, a brilliant conversationalist, and of a most agreeable and entertaining disposition, his loss is deeply deplored. He died after a few days' illness.

James Robert Jones was born at East Stonehouse, Plymouth, in 1840 October. His father was an officer in the Navy, who had seen active service and was once wounded, and who died at a comparatively early age, when the subject of this notice was very young. Mr. Jones was educated at the Free Schools at Plymouth until he was twelve years of age, and then was admitted to the Higher School at Greenwich Hospital. He displayed great aptitude in his studies, especially in astronomy and navigation. At the age of fifteen he was appointed a pupil teacher of the school. Having no taste for the sea, he was appointed assistant master in one of the schools of navigation in London under the Board of Trade, and shortly afterwards Head Master of the Navigation School at Great Yarmouth, which the Board of Trade had decided to open there. He held this appointment for seven years, during which time he married. In 1865 January, at the age of twenty-four, he was appointed Head Master of the Navigation School at Aberdeen.

Mr. Jones published several editions of a handbook on navigation for masters and mates, which was extensively used. He was an observer for the Meteorological Office, London, and for several years he compiled *Inglis' Tide Tables*, which had a large circulation in Aberdeen and district.

He was elected a Fellow of this Society on 1869 February 12.

He died 1896 March 15, leaving a widow and four daughters.

Thomas Keig was born at Kirk Santon, midway between Castletown and Douglas, in the Isle of Man, in 1829. His life was spent almost exclusively in Douglas, save for a few years passed in England. It was during his sojourn in England that he attended the evening classes of Queen's College, Liverpool, devoting himself specially to the study of English literature and drawing. His first avocation was that of cabinet-maker. This he afterwards exchanged for photography. Gifted with much artistic skill, he cultivated the art of photography with great

success down to his lamented death in the spring of 1896. He left a devoted wife and family to mourn his loss.

Though ever leading an active life, and having a share in all public events in Douglas from the year 1872, he still found time in his leisure hours for deep and extensive reading in astronomy. In the autumn of 1887 Mr. Keig founded the Manx Astronomical Society. On the top of his own house he constructed an observatory. He loved to prove everything by his own research. The moon was one favourite object of his careful study. He noted down various phenomena which seemed to contradict the universally recognised theory as to the non-existence of a lunar atmosphere. He verified night after night these results. He wrote a paper describing his observations, and drawing the conclusion that the moon must have an atmosphere, which he read before the Liverpool Astronomical Society. Mr. Keig was not only the founder but the mainstay of the Manx Astronomical Society, by ever allowing his own studio to be the welcome home of their fortnightly meetings. He was elected a Fellow of this Society on 1889 February 8, and was the first resident Manxman who has enjoyed this distinction.

As a citizen of Douglas, Mr. Keig stood forth in the front rank. Again and again he was elected chairman of the Town Commissioners, and when the town was recently created a borough, Douglas could find no worthier son than Thomas Keig, F.R.A.S., to rule and guide, as first mayor, her new and enlarged destinies.

[For the above particulars the Council is indebted to the Rev. Edmund Walsh, R.C.P., of Douglas, I.M.]

The Rev. Thomas Mackereth was born at Helsington, near Kendal, on 1823 April 28. He was of humble parentage, and was apprenticed to a plumber in Manchester; but losing his parents at the age of 20, and not finding his calling congenial, he studied for and obtained an elementary schoolmaster's first-class certificate. He began a successful career as a schoolmaster in Salford, taking up his residence at Eccles in 1860, and among his pupils are a number of prominent men in South Lancashire and elsewhere. In 1878 he left the Salford School for the pastorate of the Bolton Society of the New Jerusalem Church, and held this office till 1886, when, owing to failing health, he had to retire to his native county, taking a house at Ambleside, and removing eventually to Windermere.

While at Eccles, he erected a $4\frac{1}{4}$-inch equatorial and a transit instrument, being assisted by the late Mr. Joseph Baxendell and Mr. J. B. Dancer, both his close friends. He often lectured on astronomy, and was always ready to help and encourage young students. He continued his almost nightly observations at Bolton, but there he had to leave his equatorial, as his failing health would not permit of exposure to the night air. He was elected a Fellow of this Society on 1865 March 10, and was also

a Fellow of the Royal Meteorological Society, and a regular meteorological observer. He died on 1897 January 20, after a long and weary illness, leaving a widow, one son, and three daughters.

Samuel Hickling Parkes was born at Birmingham on 1817 April 8. He was the eldest son of Mr. James Parkes, of Handsworth, the founder of a firm of optical and mathematical instrument makers in St. Mary's Row, Birmingham, and joined his father in this business about the age of sixteen. He worked hard to develop this business, but always found time for scientific pursuits. He married Miss Emma Lloyd Kershaw, and they had one child, Mr. S. T. H. Parkes, who survives them. Mr. S. H. Parkes died on 1896 August 12. Among his papers was found the following note, which his son has kindly communicated to the secretaries. "A short obituary is always requested by the R.A.S. for insertion in their proceedings. If this must be, I wish it to be as brief as possible. No reference to early school days, &c., but simply spent a practical, uneventful life—early devotion to study of general science, especially natural history and comparative physiology. This pursued through life, while engaged in active business. Occasionally lecturing gratuitously on these subjects. Uniform endeavour to act under the influence of religious principles, and to employ talents and knowledge bestowed in useful ministrations to others. When unable to engage in active duties, wrote and published *Unfinished Worlds*."

It does not seem possible to comply with the spirit of this note better than by quoting it verbatim, adding simply that Mr. Parkes lived from 1865 to 1885 at King's Norton, where he had an observatory and a 5-inch refractor telescope. This was disposed of about ten years ago, and his later scientific observations were confined to microscopy. He was elected a Fellow of this Society on 1882 January 13.

Sir John Pender was born in 1815, and was the son of the late James Pender, of the Vale of Leven, Dumbartonshire. He was educated at the High School, Glasgow, and began a successful business career in Glasgow and in Manchester. His work in relieving the suffering during the Cotton Famine is still remembered with gratitude; but his chief work, which he began about the age of forty, was connected with submarine telegraphy. In 1857, when the late Mr. Cyrus Field organised the first attempt to lay an Atlantic cable, Mr. Pender was one of the contributors of 1,000*l.* towards the expenses. This attempt was unsuccessful, but the experience gained gave sufficient confidence for another in the following year, and this cable was actually laid, although it only worked for twenty-eight days. The next attempt was made in 1864, after considerable difficulty in getting the money together, and was only rendered possible ultimately by Mr. Pender offering his personal guarantee for a quarter of a million. After two-

thirds of this cable was laid by the *Great Eastern* it broke, and could not be recovered. Another company was formed to make a new attempt in 1866, Mr. Pender being again responsible for a considerable share of the expenses. This time not only was the cable successfully laid, but the end of the last year's broken cable was recovered, and it was completed. From this time Mr. Pender became a recognised leader in submarine telegraphy, and at his death presided over companies with a total capital of fifteen millions, and a cable mileage of 73,640 nautical miles. He was knighted in 1888, and promoted G.C.M.G. in 1892, and received many foreign orders and distinctions. His parliamentary career was a long and honourable one. He was M.P. for Totnes, 1865–66; Wick Burghs, 1872–85, 1892–95. He also contested Linlithgowshire 1868, Wick Burghs 1885, Stirling Burghs 1886, and Govan 1889. He took a keen interest in pictures, of which he had a fine collection, making it, moreover, a rule never to buy a modern picture without making the personal acquaintance of the artist.

He married, in 1840, Marion, daughter of Mr. James Cearns; and some years after her death he married, in 1851, Emma, daughter of Mr. Henry Denison, of Daybrook, Notts; and leaves two sons and two daughters. He was elected a Fellow of this Society on 1883 June 8. It may be mentioned that, on occasions when application has been made to the cable companies for facilities on behalf of purely scientific enterprise, Sir John Pender was always ready to use his influence in their favour, and his Fellowship of this Society was constantly referred to as one of the reasons for his doing so.

Wadham Locke Sutton was born at Highgate in 1815, and was the youngest son of the late Robert Sutton of Rossway, Hertford. His life was spent almost entirely in the neighbouring town of Northchurch, and at Dudswell, where he lived for some years, he erected an observatory containing a telescope of considerable size. He was a Master of the Mercers' Company in 1858–59. One of his chief interests was work connected with the Church, and he was rector's churchwarden from 1860 till his death, which took place at Northchurch on 1896 September 25, in his eighty-second year.

Mr. Sutton married, in 1858, Louisa Ann, daughter of the late Rev. William Ludlow, Vicar of Kirton, Lincolnshire. He was elected a Fellow of this Society on 1854 November 10.

Sidney Waters was born at Camden Town, on 1853 October 13. He was educated at Amersham Hall, near Reading, and showed considerable mathematical ability, as well as an ingenuity in devising and making apparatus. His life occupation was that of a merchant; but he was keenly interested in astronomy from an early age, and published his first paper in 1873 April, drawing attention to the fact that where "irresolvable" nebulæ cluster

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there also do the "resolvables." This was stated, in the first instance, in a letter to Mr. R. A. Proctor, in conference with whom much of Mr. Waters's early astronomical work was undertaken. At the next meeting of the Society Mr. Waters (not yet quite of age) was elected a Fellow, and in the "Supplementary number" for 1873, he published the isographic charts of nebulæ and clusters on which he based the above conclusion. Recently (1894 June) he revised these charts by the help of Dr. Dreyer's New General Catalogue. He also, in 1878, gave an isographic chart of the stars in the southern hemisphere. These papers represent practically the whole of his published work, but his devotion to astronomy was shown in many ways. He went to Norway in August of the past year to observe the Total Solar Eclipse, having equipped himself with a special telescope camera. He made a very fine private collection of astrolabes ; and he took a prominent part in the private business of this Society. He married in 1877 a daughter of the Rev. Edward White, and leaves a son and two daughters. Mr. Waters was grandson of the Rev. Thomas Waters and of Mr. E. Leader Williams, both of Worcester, and nephew of Mr. B. W. Leader, A.R.A., and of Sir E. Leader Williams, engineer of the Ship Canal. He died on 1896 December 14, at his residence, 44, Ladbroke Grove, W.

Benjamin Apthorp Gould was born in Boston, 1824 September 27. He entered the Boston Latin School in 1836, and graduated from Harvard College, with high distinction in classical, as well as in mathematical and physical studies, in 1844. After teaching for a year in the Latin School, he decided to devote himself to a purely scientific career. As a preparation for this he went to Europe in 1845 July, to study astronomy, working at the Greenwich Observatory three months, at the Paris Observatory four months, at the Berlin Observatory a year, at Göttingen Observatory one year, at Altona Observatory four months, and at Gotha Observatory one month. He returned home in 1848. In 1852 he was appointed to take charge of the longitude determinations of the Coast Survey. He organised, developed and extended this service, retiring in 1867. Meanwhile, in 1855, he became Director of the Dudley Observatory, in Albany, equipped and organised the institution, and carried it on without remuneration and at his private expense. He left it in 1859, after a severe struggle to preserve the institution for purposes of scientific investigation.

In 1859 he published his discussion of the places and proper motions of circumpolar stars for use as standards in the Coast Survey. These, as revised by him in 1861, together with his similar list of clock-stars, were adopted as the standards for the American ephemeris, and, as to the circumpolars, remain in such use to this day. In 1866 he published his reduction of d'Agelet's observations. About the same time he performed a similar service for the greater part of the observations made at the

United States Naval Observatory since its establishment, and also for the expedition to Chili to determine the solar parallax. In 1866 he planned and executed the work of establishing, by the Atlantic cable, the relation in longitude between European and American stations. As actuary of the United States Sanitary Commission he conducted, and published in a large volume, extensive and important researches upon Military and Anthropological Statistics and the Distribution of Population. About the same time he undertook the reduction of Rutherfurd's photographs of the *Pleiades*. The results, partially published in 1866, were submitted completely, in a elaborate memoir, to the National Academy in 1870, together with a second memoir on the *Præsepe*. He was, indeed, a pioneer in the utilisation of photography for exact astronomical measurement. About 1864 he built an observatory in Cambridge, equipped with an 8-foot transit-instrument, and, until 1867, carried on a determination of the right ascensions of all the stars to the tenth magnitude within one degree of the pole. This work was completely reduced, but the discussion and publication were postponed by his removal to Cordoba.

In 1865 he became intensely impressed with a desire to explore the southern celestial hemisphere. The opportunity to do so soon came. This project assumed at first the form of a private astronomical expedition, for which his friends in Boston had promised the pecuniary means; but, under the enthusiastic support of Mr. Sarmiento, at first as Argentine Minister to this country, and later as President of that Republic, it rapidly broadened, and finally led to the establishment by Dr. Gould of a permanent National Observatory at Cordoba. This important addition to the observatories of the Southern hemisphere, which are comparatively so few, forms an impressive monument to his memory.

It is impossible, in brief space, to describe or characterise the marvellous work here undertaken and so faultlessly pushed to completion by Dr. Gould, during the fifteen years of self-imposed exile from his native land, with unfaltering devotion and energy, in the face of difficulty and domestic bereavement. The work on the uranography of the southern heavens was finished in 1874, and was published under the title of the *Uranometria Argentina*, which will remain a classic for all time. For this work he received the Gold Medal of this Society in 1883, and in presenting it, the President remarked that, great and important as the work was, it was still but a small, and in his opinion, not the most valuable part of that which Dr. Gould had done at Cordoba. The zone observations of the stars between 23° and 80° south declination, which were the original and always the dominant object of the enterprise, were begun in 1872, substantially completed in 1877, and revised in 1882–83. This work was embodied in the Zone Catalogues containing 73,160 stars, which appeared in 1884. Parallel with this, and almost overshadowing it in importance, was

carried on the independent series of meridian-circle observations for the General Catalogue of 32,448 stars, completed in 1885. Dr. Gould, besides, left the manuscript of the remainder of his series of fifteen volumes, not then published—containing the observations and the annual catalogues, incorporated in the General Catalogue—complete to the minutest detail ready for the printer. These have since appeared from time to time—the last volume, rounding off his work, reaching Cambridge but a few hours before his death.

Another part of the work for the Cordoba Observatory, planned by Dr. Gould as a fitting extension of it, was a *Durchmusterung* of the southern sky. For this, indeed, he had provided the instrumental means and trained the assistants, it being his purpose to be ready to begin it at any time in case of unforeseen delay or accident to the other work. On leaving Cordoba he confided it to the care of Dr. Thome and Mr. Tucker, who have since so worthily conducted it.

Dr. Gould also established, under the auspices of the Argentine Government, a meteorological service, second in extent, it is believed, only to that of the United States. Upon leaving South America he intrusted this charge to the hands of his worthy successor, Walter G. Davis.

The earliest to realise and demonstrate the capabilities of photography to render service to the astronomy of precision, Dr. Gould, by his experience with the Rutherfurd plates of the *Pleiades* and the *Præsepe*, was incited to arrange to carry forward at Cordoba, on an extensive scale, a similar work upon the southern stellar clusters. His other labours there were so onerous that he confined his attention to securing plates suitable for precise measurement. Of these he accumulated about 1,400, and brought them home with him in 1885 for measurement and reduction. Without permitting himself a well-earned retirement, he turned at once tirelessly to this labour, which has been the principal occupation of the last ten years of his life. This is substantially complete, so that it will be given to the world as it came from his hand. That he might be spared to do this was his most earnest solicitude and hope.

Dr. Gould had, as we have already remarked, an enthusiasm for his beloved science far wider than the limits of what he could accomplish by personal investigation. Early in his career he had realised that astronomy had reached a stage of development in America which entitled it to a higher claim than had yet been accorded to it, and that a journal worthily supporting the dignity of a pure science would have very great influence upon its future progress. Accordingly, without ostentation, he established the *Astronomical Journal* in 1849, offering it to the use of astronomers, for the publication exclusively of original investigations. He edited and supported it until, at the end of the sixth volume in 1861, its issue was suspended, first by the war for the preservation of the Union, afterward by his absence in

Cordoba. A long-nurtured hope was realised when he was enabled in 1885 to resume its publication, and to continue it at the rate of nearly one volume annually to the present time. With careful forethought he has made due provision for its continuance.

Considered apart from the great things he accomplished, the first point that strikes us in Dr. Gould's career is the intimate way in which it is bound up with the history of his beloved science on both sides of the Atlantic, and the unique position he held, as illustrated by the number and extent of his personal alliances. It is scarcely possible to realise that he was the friend of Von Humboldt, then in his seventy-seventh year ; that it was due to the friendly interest of this great man indeed that he became the pupil, friend, and intimate in the household of the great master of modern astronomy, Gauss, then in his seventieth year ; that he was a pupil of the illustrious Encke, of the elder Struve, of Hansen, of Peters and Argelander, and the life-long friend of these and other revered men, the pillars of the science. His correspondence with them after he returned to his native land testifies to the mutual confidence that characterised these memorable associations. Following these in the next generation come Winnecke, Schönfeld, Auwers, and a numerous host besides, which to us are great names, but to Gould were fellow-pupils and associates. Of the same epoch, in America, we have Bache, Peirce, Walker, Hubbard, Coffin, Chauvenet, and Winlock. Then come the two living generations of astronomers, bringing friendships and acquaintances wide as the world itself, extending his relations to the youngest workers in the science. With such universal and intimate connection with the personal forces operating to advance astronomy in all lands, with his intense patriotism, with his strong intellectual and moral traits, he could not fail to exercise a powerful moulding influence upon the development of American astronomy. It was to this end, in preference to the satisfaction of ambition through what he could achieve by his personal contributions to the fund of knowledge, that his most earnest efforts from the beginning of his career were directed. In one of his letters to Von Humboldt, in 1850, after speaking of the dependent condition at that time of science in America, its self-distrust and intellectual timidity, he says : "This I knew before returning home, but realise it now, for the first time, to its full extent. Therefore it is that I dedicate my whole efforts, not to the attainment of any reputation for myself, but to serving to the utmost of my ability the science of my country —or, rather, as my friend Mr. Agassiz tells me I must say, science in my country." And to Encke he says, speaking of the establishment of the *Astronomical Journal*, and his fond hopes in its agency as a means of raising the astronomy of America to its proper position : "Though the labour of supporting it will prevent me from working as I otherwise should for the advancement of my own reputation, still the consciousness that I may render now

a still greater service to science reconciles me to the abandonment of a good deal of personal ambition." The same spirit breathes throughout his correspondence with Gauss, Schumacher, and other great leaders abroad, to whom he was wont to confide his projects and aspirations, and who sympathised with and counselled him in return. His letter-books are rich with similar illustrations.

And this brings us to another remarkable point about Dr. Gould's career. If we were asked to place the finger upon the epoch marking the birth, or regeneration, of American astronomy, we should feel inclined to name the date 1845 July, when Gould placed his foot upon the steamer from Boston with the avowed and definite purpose to devote himself to a life purely of scientific research. Up to that time the instance of a man doing this as his only earthly aim, while unassured of a professor's chair or similar appointment, and not as a means of livelihood, was in America absolutely unknown.

He inspired a new breath into American astronomy. The new atmosphere which he brought with him from Germany, where he caught the spirit of the great masters under whom he studied, became gradually transfused through the States. His enthusiasm for the introduction of better means and methods of research was caught by his compatriots, their courage in the effort to regenerate our science was sustained, and transmitted through various channels to the next and to the present generation.

Dr. Gould married, in 1861, Mary Apthorp Quincy, daughter of Hon. Josiah Quincy. She died in 1883. Her sympathy with and influence upon his life work may be most reverently spoken of by recalling the affecting lines of his dedication of the great Zone Catalogues: "This Catalogue of Southern Stars, the fruit of nearly thirteen years of assiduous toil, is dedicated to the beloved and honoured memory of Mary Apthorp Quincy Gould, to whose approval and unselfish encouragement the original undertaking was due, by whose sympathy, self-sacrifice, and practical assistance its execution was made possible, who bravely endured privation, exile, and afflictive bereavement that it might be worthily finished, but who has not seen its completion."

Dr. Gould received the degree of Ph.D. from Göttingen in 1848, and that of LL.D. from Harvard in 1885, and from Columbia in 1887. He was For. Mem. Roy. Soc. (London); For. Assoc. Roy. Astr. Soc. (London); Cor. Mem. Acad. Sci. (Institut de France); Acad. Imp Sci. (St. Petersburg); Kön. Akad. Wiss. (Berlin); Kön. Ges. Wiss. (Göttingen); Kais. Akad. Wiss. (Vienna); Bur. d. Long. (Paris). He also received the order Pour le Mérite from Prussia..

[For the above notice the Council is indebted to Mr. S. C. Chandler.]

Hugo Gyldén was born in Helsingfors, Finland, on 1841 May 29. The only son of his parents, he received from them the

most careful nurture and education, which in his case brought a rich reward. After completing his university course, he went to Gotha, in 1861, that he might obtain from the illustrious author of the *Fundamenta Nova*, *Perturbations qu'éprouvent les Comètes*, *Zweckmässigen Methode die Störungen der kleinen Planeten zu ermitteln*, &c., a thorough acquaintance with the (then new) methods of the theory of perturbations. In 1862 he returned to Helsingfors to practise at the University as *docent*, but he soon left for Pulkowa, where he worked hard in the observatory till 1871. In that year he was called to Stockholm, being appointed Director of the Observatory of the Academy of Sciences ; and this position he held till his death on 1896 November 9, in spite of flattering invitations to undertake the direction of other observatories—Helsingfors, Gotha, Göttingen, &c.

It is always of interest to study the history of a great man's work. In the case of Gyldén it is remarkable how, in spite of its diversity, a fundamental connection can be traced throughout. If we specially consider his researches on the groundwork of planetary theory, the logical order of the development is at once apparent. The methods of Hansen are devised especially to simplify numerical calculations in order to lighten the mechanical work in studying celestial motions. Gyldén's work in the first period bears traces of Hansen's influence—defining as the first period that in which he endeavoured to simplify the calculation of perturbations on familiar lines. The one investigation dealt with minor planets, the other with comets, the two together representing an attempt to simplify the problems of motion in orbits of moderate and large eccentricity. The valuable series of publications which resulted from these two inquiries is well known to astronomers. He treated the second most completely, and was thus led to complex mathematical researches, preparatory to the second period.

The unsatisfactory nature of methods hitherto known, all based on the Keplerian ellipse, had long ago attracted Gyldén's attention, and in the course of the above-mentioned investigations he devised the means of attacking the fundamental problem of the theory, the absolute orbits of the planets. The second period, which occupied the last 16 years of his life, was devoted to this problem. The principal results as yet published are the memoirs *Ueber die Convergenz*, &c., the *Nouvelles Recherches*, and the *Théorie des Orbites absolues*, vol. i. Of this last work vols. ii. and iii. are still to come. In the same connection Gyldén undertook an investigation on the planet *Hilda* and the satellite *Hyperion*, which are known to have analogous motions. To give details of this work here would take too long.

This is a brief indication of Gyldén's chief work, but his catholic genius did excellent work in other departments of astronomy. His researches on the rotation of the Earth and on stellar parallax are well known to astronomers. During his stay

at Pulkowa he was charged with the vertical circle to determine the declinations of the Pulkowa fundamental stars, and this led to his devoting attention to various questions of stellar astronomy. A man of his stamp could not be satisfied with merely making the observations, which he regarded as merely the starting-point for real astronomical work. He undertook a discussion of the theory of refraction, which forms the basis of the Pulkowa refraction tables. His memoir in the fifth volume of the Pulkowa observations gives a faithful picture of him as a practical astronomer. Finally, to give some idea of his versatility, we may mention the regions in which he did and published work of more or less importance : the theory of the motions of planets and comets, mathematical analysis, the problem of rotation, stellar parallax and proper motion, theory of refraction, variable stars, cosmogony, popular astronomy, biography, philosophy. The number of his published works and memoirs exceeds 200.

The astronomical world will mourn Gyldén's death, not only because a distinguished man of science of whom much might yet be expected has been cut off in the prime of life, but also because he has been snatched away from his most important researches on planetary motion just as he was about to gather the ripe fruits of his labours. This refers more especially to the second and third parts of his *Théorie des Orbites absolues*, and to the application of his methods to special cases of motions of the minor planets and satellites, for it was here that we might look for the most important results of his work in revising the theory of planetary motion. Although it is believed that he has left the work in MS. so nearly complete that it can be edited and published with comparatively little trouble, still it can no longer come from his own hands, and herein lies the bitter sadness of Gyldén's early death. On the other hand, it may be stated with confidence that the method of investigation in the planetary theory initiated by Gyldén has been established on a firm and permanent footing. For this no better testimony is needed than the number and names of those who have studied Gyldén's theory. That which he strove for he in the main accomplished, and the accomplishment required not only all his skill, but all his own great energy.

Gyldén possessed in the highest degree those qualities which make a scholar in the true sense of the word. His lofty conception of science and its aims was an inspiration to those who had the good fortune to be intimate with him ; personal intercourse with him was a perfect stimulus towards scientific activity.

[For the above notice the Council is indebted to Dr. O. Backlund, Director of the Pulkowa Observatory.]

Carl Nicolaus Adalbert Krueger was born on 1832 December 3 at Marienburg, in West Prussia. He was at school, first at Elbing, and later at Wittenberg. In 1851 he entered the Berlin University to study mathematics and science, and soon

showed an especial preference for astronomy. But he did not devote himself exclusively to it until 1853, when he left Berlin for Bonn, and found in Argelander a master who understood better than all others how to inspire his pupils with a love of astronomy. Argelander soon remarked the ability and energy of his young pupil, who was not deterred by any amount of labour, and even before he took his Doctor's degree in 1854 August (for which his dissertation was "De ascensionibus rectis a Flamsteedio quadrantis muralis ope observatis"), appointed him, in the autumn of 1853, Second Assistant at the Bonn Observatory. He thus shared with Schönfeld the work on the recently undertaken Durchmusterung of the northern heavens, a task which called for all the energies of the workers if it was to be completed within a moderate time. It was finished in six years, and the results are published in vols. iii.–v. of the *Bonn Observations*. But Krueger showed himself a true pupil of Argelander, in that even this heavy work did not exhaust his activities. So far as it allowed, he observed comets and planets with the ring micrometer, variable stars, and computed numerous cometary and planetary orbits, especially that of the planet *Themis*, which he made his own particular care without intermission till his death. Two memoirs on the orbit of *Themis* appeared in 1866 and 1873 in the *Transactions of the Society of Finland*. A third memoir was projected, but unfortunately not completed. He also determined stellar parallaxes with the heliometer, especially those of 70 *Ophiuchi*, *Lalande* 21258, and *Arg. Oeltz.* 17415-6, and his triangulation of the cluster *h Persei* has been a pattern for other subsequent workers in the same field.

He was appointed First Assistant in 1859, and qualified as Privatdocent in the University in 1860. But in 1862 June he was called to Helsingfors as Professor of Astronomy and Director of the Observatory, which his honoured master, Argelander, had founded and directed until his appointment at Bonn. Here he selected for special attention the meridian circle, although observations of comets with the refractor were not neglected. His plan was to reobserve the stars of the Abo Catalogue, and to make special observations in conjunction with Argelander, but both projects were superseded by the zone observations for the *Astronomische Gesellschaft*, Krueger being one of the first to give in his adherence to the scheme. The 8-foot transit instrument seemed to him more suitable for the observation of his zone ($+55°$ to $+65°$) than the smaller circle, and he read the declinations on an auxiliary circle. The work was conducted with characteristic energy; the first zone was observed on 1869 August 30, and in 1876, when Krueger left Helsingfors, more than two-thirds of the whole was completed.

Besides observational work, Krueger found time at Helsingfors for considerable literary activity. First he reduced and published the Bonn heliometer observations, then he was continually busy with the orbit of *Themis*; and to this epoch (1868)

belongs the computation of the orbit of Comet 1785 II, which was interesting as having elements somewhat resembling those of Comet 1867 III. His idea (1864) for the barometer compensation of a pendulum, by using an imperfect vacuum, was an important step in practical astronomy. His publication of the observations of the Helsingfors Magnetic and Meteorological Observatory from 1845–56, during which period the thermometer was read every twenty minutes, afforded an opportunity for a complete discussion of the mean temperature of Helsingfors, which appeared in 1874.

In 1876, on Hansen's death, Krueger was appointed Director of the Gotha Observatory. Had this promotion meant the interruption of the zone observations, he might have hesitated to accept it; but the Helsingfors University authorities generously lent the transit instrument to the Gotha Observatory for some years. Here he recommenced his work on 1877 July 31, after re-erecting the meridian piers. His completion of it was simultaneous with his leaving Gotha in 1880; and the few necessary revision observations were made by Donner at Helsingfors after the return of the instrument.

We come now to the last period of Krueger's life, during which he was Director of the Kiel Observatory and Editor of the *Astronomische Nachrichten*. It was not without many searchings of heart that he undertook these duties; but a mere glance at the forty volumes which appeared with his name on the title-page is sufficient to show that he was the right man in the right place. As soon as his editorial duties allowed him, he proceeded with the final discussion of his zone observations, which were published by the Helsingfors University in two volumes (1883 and 1885). Astronomers were thus able to judge of the quality of the work long before the appearance of the final Catalogue of 14,680 Stars, which was published by the *Astronomische Gesellschaft* in 1890.

In 1882 Krueger, as Editor of the *Astr. Nach.*, was appointed Director of the new "Centralstelle für Astr. Telegramme," and performed his new duties with the greatest zeal. He made it a point that the elements and ephemerides of the newly discovered comets should appear in the *Astr. Nach.* at the earliest possible moment, and computed not a few of them himself.

About the year 1889 an affection of the heart declared itself, and from the autumn of 1895 this and other complications made his illness assume a serious character, which was soon seen to be hopeless. He lingered some six months in great pain, and died on 1896 April 21.

Krueger was elected a Foreign Associate of this Society on 1879 January 10. Many other learned societies conferred similar honours upon him, especially the Finnische Societät, the Sächsische Ges. der Wiss., and the Berlin Akademie. He married a daughter of his master, Argelander, and had one daughter.

[His son-in-law, Dr. H. Kreutz, has kindly abridged this

notice from his somewhat longer account in the *Vierteljahrsschrift der Ast. Gesell.*]

Didrik Magnus Axel Möller, the son of a civil officer in the province of Schonen, in South Sweden, was born 1830 February 16. He shewed mathematical ability of a high order almost from infancy, and entered the Lund University at an exceptionally early age. On passing his examination in 1853 he was immediately nominated Docent, in 1855 he was made an Observer, in 1861 Extraordinary Professor, and in 1863 Ordinary Professor. His predecessor in the chair was much occupied with public matters. Möller had practically undertaken the professorial work from the time he was appointed Docent, with the exception of a period in the years 1858–59, during which he travelled in mid-Europe with the object of adding to his scientific knowledge, a short time spent in visiting Pulkowa in 1861, and a few weeks in the summer of 1860, when he took part in the solar eclipse expedition to Spain.

In the years which followed Möller was on several commissions for the remodelling of the higher grade educational institutions of Sweden. His interest in all educational matters was very keen, and his opinion always commanded the greatest respect. For a long time he was Rector of his University, and would have held this office till his death but for his own wishes, which caused his resignation in 1895. Long after the conclusion of his duties as teacher he continued to superintend the final examinations of the students. His ability further shewed itself in various matters of administration, where his sound common sense and financial knowledge were of the greatest value. His fine constitution resisted the hardships and fatigues of a hard-working observer's life for many years ; but in the spring of 1896, during a journey in North Sweden, he caught a severe cold. This left behind an affection of the heart which put a sudden end to his busy life on 1896 October 25.

Möller's scientific work began in 1853 with a determination of the longitude of Lund, after which he undertook the determination of the orbit of Comet 1852 III. Then the peculiarities of the orbit of Faye's Comet absorbed his attention ; from 1860 onwards he undertook a long series of investigations on this subject, and by extraordinary care and completeness in his work he finally succeeded in determining the orbit with extreme precision, and gave ephemerides for the returns in 1865, 1873, and 1880–81 with a success which is well known. From the first this work attracted the notice of the astronomical world, and practical recognitions of its value came from various quarters. In his honour the Comet has been named Faye-Möller ; and he was awarded the Gold Medal of this Society in 1881. In presenting the medal, the President, Mr. J. R. Hind, who was well qualified to speak with authority on the occasion, reminded the Society that the class of computation involved in such investigations is

of a high order, and "does not admit, as is often the case with heavy masses of astronomical calculations, of being set out for the ordinary computer. Considerable mathematical knowledge, and knowledge of refined methods, and of their adaptability to particular cases, is absolutely essential; and Professor Möller's success has proved that he possesses this knowledge in an eminent degree."

Another member of our system which occupied Professor Möller's attention was the minor planet *Pandora*, the perturbations of which he calculated by Hansen's method. Many minor investigations appear in the publications of the Lund University, and it is to be remembered that the observatory itself wherein these observations were made is due to Möller. At the time of his appointment as Professor the Lund University only possessed a few very ordinary astronomical instruments; but as a result of his strong and urgent representations the University built a new observatory and equipped it very completely. In this Möller worked zealously for many years, making numerous observations, especially of planets. He was an indefatigable worker. Whatever he undertook he carried through to the end with all his energies. His loss will be severely felt by all who knew him and had felt the influence of his strong and upright character.

[For this notice the Council is indebted to Dr. Folke Engström.]

Hubert Anson Newton was born on 1830 March 19, at Sherburne, in the central part of New York State, the fifth son of a family of seven sons and four daughters, children of William and Lois Butler Newton. Both parents, who traced back an ancestry to the first settlers of Connecticut, had migrated westwards and settled on a large farm which yet remains in the family. William Newton was a man of considerable enterprise, and undertook the construction of the Buffalo section of the Erie Canal; his wife was famed for her mathematical powers among her near acquaintance, so that the natal gifts to this one of their children are clearly manifest.

Young Newton fitted for college at the schools of Sherburne, giving early promise of mathematical taste. He entered Yale at the early age of sixteen, in the class graduating in 1850. In the college records he appears as a speaker at the junior exhibition of his class, with "India" as his theme, and in the graduation list he won an "oration" stand, though his name is not on the list of commencement speakers. More significant of his gift was the winning of the first prize for the solution of mathematical problems.

After graduation he pursued his studies; was appointed tutor at Yale in 1852, taking full charge of the department of mathematics during the illness of the senior professor at that time; and in 1855 he was elected full professor at the early age of twenty-

five, probably the youngest graduate of the college to reach that honour.

Entering upon this charge after a year's study in Europe, he filled it with signal success until his death, which occurred in New Haven, on 1896 August 12, being then the senior professor as regards length of service in the college. His life was outwardly uneventful, passing away quietly in the duties of his chair, with occasional trips to Europe.

His efforts in the cause of education were shown in many ways, amongst others in the securing of an adequate presentation of the metric system in the school arithmetics of the United States. His contributions to science were in part in pure mathematics, dealing mainly with the analysis of curves; but his name will be chiefly connected with his researches on meteors and comets, a brief enumeration of the most important of which will not be out of place here.

Professor Newton's papers on meteors began to appear in 1860, and dealt at first with a few special cases of observed fireballs; he soon, however, attacked the subject on broader lines. In 1864 he published his well-known discussion of all the original records of the November star shower, finding evidence of thirteen showers since A.D. 902, and showing clearly the existence of the cycle of thirty-three and a quarter years. Considering the phenomenon to be caused by a closed ring of meteoroids revolving around the Sun, he made it clear that the period must have one of five values, ranging from a little less than half a year to the thirty-three and a quarter years of the cycle. He inclined toward one of a little less than one year, but pointed out the test supplied by the variation of the node he had found to amount to 1″·7 annually, of which only one half is caused by precession, and the rest must be due to planetary perturbations. As will be remembered, Professor Adams carried out this test, and showed that the long thirty-three and a quarter year period alone gave the correct nodal displacement. The complete verification of Newton's prediction of a large display of meteors on 1866 November 13 is also a familiar matter of history, together with the identification of the orbit of the meteoroids then seen with that of the comet which preceded them about a year.

Meanwhile, in 1865 March, Professor Newton had published a memoir in which from a large number of observations of sporadic meteors he derived their numbers, their frequency in the space traversed by the Earth, their velocity and the conclusion that their orbits resemble those of comets, thus, doubtless, paving the way for the now generally accepted theory of meteors. He also organised parties for the observation of the expected shower, and deduced the relative numbers of shooting stars seen by various numbers of observers.

In 1875, in a paper on the "Origin of Comets," he took up the question as to whether the comets originated from matter in stellar space extraneous to the solar system or formed part of the

primeval solar nebula. Arguing from the distribution of their orbits, he finds that both aphelia and inclinations point to an origin foreign to our solar system. In connection with this he discussed the effect of large planetary perturbations of the planets on the distribution of cometary orbits, a subject he recurred to subsequently in 1891, in a memoir on the "Capture of Comets by Planets, especially *Jupiter*." In this he showed that of 1,000,000,000 comets coming inside *Jupiter's* orbit with parabolic velocity 126, 839, 1,701, and 2,670 will respectively be so retarded by *Jupiter* as to have periods respectively less than $\frac{1}{2}$, 1, $1\frac{1}{2}$, and 2 times that of *Jupiter*.

The Biela meteors of 1885 led him to express his view that these, together with those seen in 1872, must have left the neighbourhood of the parent comet about 1841 or 1842, and in order to account for the rapid disintegration and dispersion, he thought the various particles might have been subject to a varying attraction of the Sun, somewhat in the manner observed in the repellent forces by which the cometary tails are caused.

Professor Newton's last considerable contribution to meteoric science was on the orbits of those meteorites or stones which are in our cabinets, and which were seen to fall. From 265 observed falls, of which 210 only gave the hour and 116 gave the direction also, he found that all but 7 of the 116 moved in orbits having direct motion, and their perihelion distances in general were less than the Earth's radius. At the time of his death he was engaged in editing a collection of a large number of meteor-orbit determinations, mainly observed in America; and it is hoped that this work may be brought out before long.

These investigations, together with numerous smaller ones, did not fail to command the attention and respect of his fellow-scientists, and received both at home and abroad deserved recognition. Professor Newton was one of the original members appointed by Congress to constitute the National Academy of Sciences; was vice-president of the mathematical section of the American Association for the Advancement of Science in 1875, when his retiring address took the form of a strong plea for more study of mathematics by men of science; and president of the Association in 1885, when his presidential address was a synopsis of meteoric lore up to that date. In 1872 he was elected an Associate of the Royal Astronomical Society, in 1886 an Honorary Fellow of the Royal Society of Edinburgh, and in 1892 a Foreign Member of the Royal Society of London.

Professor Newton was deeply interested in the welfare and development of his *alma mater*, and had great influence in the councils of the college and university. The Yale Observatory, when organised in 1882, was placed under his direction, and although he nominally resigned the directorship in 1884, the institution remained under his charge, and may be said to owe its existence to his untiring efforts and personal sacrifices in its behalf.

In personality Professor Newton was most gracious and kindly, and in all things simplicity itself. He was tireless in his efforts to aid poor students at Yale in securing an education, and not a few have owed to him the means of their college careers He also found time from his numerous duties to devote to the political service of his co-citizens, and served as alderman in the New Haven City council.

Professor Newton married in 1859 Anna C., daughter of the Rev. Joseph C. Stiles, of Georgia. She survived him but three months, leaving two daughters.

François-Félix Tisserand est né à Nuits-Saint-Georges, dans le département de la Côte-d'Or, le 13 janvier 1845. Après de bonnes études littéraires il entra, en 1863, à l'Ecole normale supérieure. Le directeur se plaisait, dans les comptes rendus annuels des travaux de l'école, à signaler l'élève Tisserand à ses camarades comme leur donnant tous les bons exemples : à un talent qu'on pressentait Tisserand alliait une modestie rare et le sentiment du devoir.

Sur l'offre de Le Verrier, Tisserand entra, en 1866, comme astronome adjoint à l'Observatoire de Paris. Il fit successivement partie du service méridien, du service géodésique, dont Villarceau était chef, et de celui des équatoriaux. Une thèse consacrée à l'exposition, d'après les principes de Jacobi, de la méthode suivie par Delaunay dans sa théorie du mouvement de la Lune marqua brillamment les débuts scientifiques de Tisserand, qui, peu après, partait en compagnie de MM. Stephan et Rayet pour aller observer sur les rivages de la presqu'île de Malacca la fameuse éclipse de Soleil du 18 août 1868.

Tisserand n'avait que 28 ans quand il fut envoyé à Toulouse pour y réorganiser l'observatoire. Il s'acquitta de cette tâche avec une rare distinction. Les ressources étaient modestes et le personnel faisait défaut. Tisserand devina la vocation astronomique de MM. Perrotin et Bigourdan, qu'il sut s'attacher. Il institua des observations aussi importantes que variées sur les satellites de *Jupiter* et de *Saturne*, les étoiles filantes, les tâches du Soleil ; plusieurs petites planètes furent découvertes.

En 1878 Tisserand recueille la succession de Le Verrier à l'Académie des Sciences ; la même année il entre au Bureau des Longitudes et est appelé à suppléer Liouville à la Sorbonne. A partir de 1883, il occupe la chaire de Mécanique Céleste, d'abord comme suppléant, puis comme successeur de V. Puiseux. Ses obligations de professeur ne l'empêchèrent pas d'aller observer, en 1882, à la Martinique, avec MM. Bigourdan et Puiseux, le passage de *Vénus* sur de Soleil ; le même phénomène l'avait amené, en 1874, au Japon, avec M. Janssen.

C'est à partir de 1883 que Tisserand prit vraiment possession de lui-même. Le devoir, qui s'accordait avec son goût, de parcourir le cycle entier de la mécanique céleste allait le pousser à l'exécution d'un grand ouvrage, Le *Traité de Mécanique Céleste*,

dont l'objet a été de coordonner toutes les recherches, de faciliter la lecture des mémoires originaux, en somme, d'exposer les progrès accomplis depuis Laplace. Plusieurs parties de la science ont été enrichies par lui de conclusions souvent très importantes, toujours nettes et élégantes. Ses recherches sur la forme générale des expressions des perturbations, sur le rôle des petits diviseurs et la libration des petites planètes se rattachent à sa thèse de docteur. Tisserand a toujours estimé que la théorie de la variation des arbitraires de Lagrange, dont la méthode de Delaunay procède, suffisait pour aborder les questions les plus hautes. Quelques feuillets provenant de leçons de l'incomparable professeur V. Puiseux sur cette théorie constituaient, Tisserand aimait à le redire, son meilleur instrument de travail. Les calculs, il est vrai, sont souvent compliqués ; mais les calculs algébriques ou même numériques n'effrayaient pas Tisserand, qui les conduisait jusqu'au terme avec une sûreté extraordinaire.

L'article du *Bulletin Astronomique* (1889) "Sur la Théorie de la Capture des Comètes Périodiques," a été l'un des plus goûtés par les astronomes, et le *critérium* qui permet de reconnaître si des comètes font ou non partie de la même famille est maintenant connu de tous. C'est la lecture de l'ouvrage élémentaire *General Astronomy* de M. Young qui engagea Tisserand à examiner d'une manière plus précise cette théorie de la capture des comètes. On peut rapprocher ce beau morceau des notices admirables de simplicité et de justesse parues dans *l'Annuaire du Bureau des Longitudes*. Ces notices très étudiées se trouvent réunies pour la plupart à la fin de la *Cosmographie*, publiée avec M. Andoyer.

Les théories des satellites l'ont surtout captivé. Le tome iv. de son *Traité de Mécanique Céleste* montre toute la part qui lui revient dans ces études si intéressantes, où le géomètre rencontre, sans être condamné à des calculs rebutants, les circonstances les plus variées jusqu'à la difficulté grave entre toutes d'un extrême rapprochement des corps en présence. Il avait attiré, l'un des premiers, l'attention des astronomes sur les particularités du système de *Titan-Hypérion* (*The Observatory*, t. iii). Il mit en évidence, par la seule puissance du calcul, l'aplatissement de *Neptune* que les lunettes ne pourraient déceler.

Il n'est pas possible de passer sous silence une œuvre à laquelle Tisserand a donné beaucoup de son temps : le *Bulletin Astronomique*. Pour lui ce n'était pas seulement un instrument utile de travail, mais encore un moyen d'activer le mouvement astronomique. En rapprochant les derniers volumes de la collection des premiers, on peut juger de la transformation féconde de l'esprit de Tisserand. Son autorité de savant s'affermit, et en même temps la souplesse, l'étendue de son esprit s'accusent toujours plus. C'est ainsi qu'il est question à la fois dans le seul volume de 1895 : des étoiles filantes ; du nouveau satellite de *Jupiter* ; du calcul des orbites circulaires ; d'une inégalitée à longue période de l'étoile variable *Algol*, dont la cause est rattachée à l'aplatissement de l'étoile principale ; de la vitesse

radiale des nébuleuses ; du mouvement propre du Soleil ; enfin de la libration des petites planètes.

La nomination de Tisserand à la direction de l'Observatoire de Paris, après la mort inattendue du regretté amiral Mouchez, en 1892, lui traça de nouveaux devoirs. Sans doute il avait à cœur de mener à bien l'œuvre principale de son existence de savant ; mais il ne négligea pour cela aucun détail de l'administration de l'établissement. Il sut trouver temps pour tout en mettant chaque chose à sa place. Quel guide précieux on aurait eu en lui alors que satisfait d'avoir achevé son traité il aurait donné le meilleur de lui-même aux questions d'astronomie pratique ! Son étude toute récente des variations de la pendule normale causées par les variations du baromètre marquait un premier essai dans cette voie. Il n'a pas été, comme son prédécesseur, l'homme des initiatives hardies, mais dans quelle mesure il a contribué comme président du Comité de la Carte photographique du Ciel, par sa direction, en même temps si bienveillante et si ferme, à aplanir les difficultés, à assurer le succès de la grande entreprise scientifique de l'amiral Mouchez ! Ce fut pour lui une joie profonde que de recevoir les témoignages d'estime de tous les astronomes réunis, à Paris, au mois de mai dernier, à l'occasion du Congrès astrophotographique.

Peu de mois après, dans la nuit du 20 octobre, Tisserand était enlevé subitement à l'affection de sa famille, de ses amis et de ses élèves, à l'estime profonde de tous. Rarement autour d'un cercueil put-on voir une pareille unanimité de regrets. C'est que Tisserand avait reçu en don, à un degré éminent, les qualités du génie français : la clarté, l'élégance, la justesse, le bon sens ; en même temps on pleurait la disparition d'un homme droit, guidé par les principes d'équité et de justice, simple et modeste comme au début de sa carrière, naturellement bon, désireux de tout concilier, plein de sollicitude pour les jeunes gens débutant dans la carrière scientifique. O. Callandreau.

[For the above notice the Council is indebted to M. O. Callandreau.]

Proceedings of Observatories.

The following reports of the proceedings of observatories during the past year have been received from the Directors of the several observatories, who are alone responsible for the same :—

Royal Observatory, Greenwich.

With the transit circle 12,456 observations of transits and 10,856 of meridian zenith-distances were made in 1896. The total number of stars observed is 3,454. The observations for the Ten-year Catalogue, which will contain about 7,000 stars, including 4,000 circumpolars, are now completed. The preparation of the catalogue is in progress ; the mean R.A. and N.P.D. for the years 1887 to 1895 have been entered on separate sheets for each star, and the precessions and secular variations computed in duplicate.

For the next Ten-year Catalogue it is proposed to observe all stars of the ninth magnitude and brighter within 26° of the Pole to serve as fundamental points of reference for the plates of the Greenwich Zone of the Astrographic Chart and Catalogue, Declination 64° – 90°. A working catalogue of these stars for the epoch 1900 is being prepared and is about half finished.

The Moon was observed 121 times with the transit-circle ; the mean error in R.A. of Hansen's Lunar Tables with Newcomb's corrections as deduced from these observations is $-0^{s}\cdot088$. The errors for the years 1883–96 are as follows :—

	s		s		s
1883	+0·031	1888	+0·090	1893	+0·034
1884	+0·018	1889	+0·010	1894	−0·016
1885	+0·024	1890	+0·020	1895	−0·066
1886	+0·029	1891	+0·079	1896	−0·088
1887	+0·059	1892	+0·083		

The progressive change of the error since 1891 is noticeable.

The number of observations of zenith distance of stars by reflexion and directly was 520. The apparent correction to the nadir observations deduced from these which has been consistently

negative throughout the year is $-0''.43$. For the years 1890 to 1895 the corrections are $+0''.08$, $+0''.07$, $-0''.25$, $-0''.34$, $-0''.27$ and $-0''.26$. The increase of this discordance suggested an examination of the screws of the microscope micrometers and of the telescope micrometer. The former shewed signs of wear, but the reversal of three of the screws has successfully eliminated the effect of wear from the mean of the six microscopes. The errors of the mean readings, as determined in 1886, when the screws were new, in 1893, and in 1896 November are as follows :—

Error of the Mean of the six screws in	Revolution of the Screw							
	9^r	0^r	1^r	2^r	3^r	4^r	5^r	6^r
	$''$	$''$	$''$	$''$	$''$	$''$	$''$	$''$
1886	−0·13	−0·07	+0·03	−0·06	+0·06	0·00	−0·06	+0·10
1893	−0·29	−0·11	−0·11	+0·03	−0·03	0·00	−0·09	−0·11
1896	−0·14	−0·02	−0·02	−0·02	+0·02	+0·10	−0·04	−0·19

The telescope micrometer which was new in 1891 shows considerable wear, though the observations for determining it are not yet completed. It has not yet been ascertained whether the wear of this screw is a sufficient explanation of the change in the apparent correction to the nadir deduced from the reflexion observations.

The observations of zenith distance of pairs of stars at nearly the same N.P.D., the one directly and the other by reflexion, alternately on alternate nights have been continued, giving ninety-seven determinations of the R−D discordance. The similar observations made in 1895 did not show any marked difference from the R−D discordance determined in the usual way.

During January the series of observations with the personal equation machine begun in 1895 was continued on six days. The observations of 1895 and 1896 have all been reduced, giving the personality of six observers for transits of the limbs of the Sun or Moon and of stars.

The Moon has been observed with the altazimuth in the first and last quarters as in previous years, fifty-eight observations being made in the year.

The new altazimuth pavilion and dome were completed early in January, with the exception of a wooden observing floor and moveable roofs over the collimators, which were not finished till August.

On the completion of the observing floor the instrument, whose erection was finished in May, was examined, and serious discordances were found in the readings of the circles under the different microscopes, depending on the direction in which the instrument was last turned. Experiments have been made under Mr. Simms' direction, which show a flexure in the axis; and means are being arranged, in conjunction with him, for stiffening the axis.

Three comets were observed during the year with the Sheepshanks' equatorial—Comet (*a*) 1896 (Perrine-Lamp) on 10 nights, Comet (*b*) 1896 (Swift) on 20 nights, and Comet (*f*) 1896 (Perrine) on 4 nights.

Twenty-six occultations of stars by the Moon were observed during the year. The occultation of *Jupiter* and his satellites on June 14 was observed by five observers; 32 phenomena of *Jupiter's* satellites were also observed.

With the 28-inch refractor 220 double stars have been observed on 91 nights, each star being observed on the average on 2 nights. Of these stars 45 were less than 0″·5 apart, 68 between 0″·5 and 1″·0, and 54 between 1″·0 and 2″·0. The following lists contain some of the more interesting stars measured, in the first the components of the double being of nearly the same, and in the second of widely different magnitudes.

	Distance.	Magnitudes.			Distance.	Magnitudes.	
	″				″		
κ Pegasi	0·10	4·3	5·0	γ^2 Andromedæ	0·20	3	5
β 524	0·22	5·5	6·5	99 Herculis	0·60	6	11
β 800	0·21	6	6	τ Cygni	0·60	4	10
Σ 1728	0·15	6	6	β 1251	1·2	6	11·5
Σ 1639	0·15	6	6·5	ζ Herculis	0·54	3	6
				ζ Aquilæ	5·6	3	15

The satellite of *Neptune* has been measured on 4 nights, the diameter of *Neptune* on 2 nights, and the diameter of *Mars* on 6 nights with the bifilar micrometer. A series of comparative measures of *Jupiter's* diameter with the bifilar and double image micrometer was communicated to the Society and published in the *Monthly Notices*, 1896 May. A water-tank has been placed on the flat of the lobby of the dome to supply the driving-clock of the equatorial, and has made a material improvement in the steadiness with which the telescope is driven.

Sir Henry Thompson's valuable gift to the Observatory of an equatorial with a photographic refractor of 26-inches aperture mounted on one end and a Cassegrain reflector of 30 inches on the other end of the declination axis is being erected in the New Physical Observatory under the 30-foot dome. The equatorial and the refractor were constructed by Sir Howard Grubb; the figuring of the mirrors and supervision of the construction of the reflector were kindly undertaken by Dr. Common. The Merz refractor ($12\frac{3}{4}$-inch) is mounted as a guiding telescope for the refractor, and the Thompson photoheliograph is also attached to the 26-inch refractor. A new spectroscope adapted for photography has been made by Mr. Simms for use with the reflector or refractor.

With the astrographic equatorial 365 plates with 722 exposures were taken on 111 nights. Of these 101 have been

rejected—viz., 15 as not coming up to the standard in showing faint stars, 13 from the *réseau* being imperfectly printed, 15 because of wrong setting, 16 owing to faults in the plate or in development, 10 owing to fogging of the plates, 11 because the exposures were interrupted by cloud, and 21 from miscellaneous defects. Of the 264 successful plates, 96 are for the chart, 131 for the catalogue, 7 are of standard areas, and 30 were taken for the adjustments of the instrument.

As the work advanced towards the pole the change of orientation resulting from the errors of collimation and inclination of the declination axis of the equatorial introduced difficulties which made it necessary to correct these errors mechanically. From measurements of trails on plates taken near the pole and equator and in reversed positions of the telescope it was found that the errors of collimation and inclination of declination axis were each $-6'$. These were eventually reduced on December 15 each to $+0'{\cdot}6$—one-tenth of the original amount—by the insertion of thin plates of copper between the telescope and its cradle, and in the cube of the cross-head.

The following table shows the progress of the photo-mapping of the heavens to the end of 1896 :—

	Catalogue.	Chart.
Number of successful fields on 1895 Dec. 31	685	479
Number „ „ taken in 1896	112	94
Number previously passed rejected during 1896 ...	28	89
Number of successful fields 1896 Dec. 31	769	484
Total number still required	380	665

The eighty-nine chart plates which are rejected are unsuitable for reproduction, though in most cases good plates otherwise. Since the last report, positives on glass have been taken of 321 chart plates, which, added to the thirty-seven reported last year, gives a total of 358. The rest of the chart plates are being copied.

During the year the rectilinear co-ordinates and diameters of the 6^m and 3^m images have been measured on 211 plates. Of these, 125 plates were measured for the first time, and eighty-six were remeasures, the plates being reversed in the holder of the micrometer. The complete remeasurement of the plates in the reversed position which has been undertaken with a view to securing increased accuracy in the results has been found to be of great advantage in the detection of errors, and for the elimination to some extent of personality in measurement. The progress made with the measurement of the photographs to 1896 December 31, is as follows : The 6^m and 3^m images on all the plates or halves of plates between 65° and 68° N. Decl. have been measured once. From 65° to 66° they have been measured twice. The southern halves of the plates in zone 65° have been measured once for two-thirds of the zone, and twice for one-third.

Altogether 252 plates have been measured once and eighty-six twice.

During the year 126 plate constants have been determined. To the end of 1896, plate constants have been computed for the whole of zone 66°, and for large portions of zones 65° and 67°; altogether for 198 plates.

The division errors of the *réseau* Gautier, No. 35, have been determined. Five plates of the same field have been measured direct and reversed by one observer, and a plate has also been completely measured direct and reversed by five measurers, giving ten sets of results for the determination of personality of the observers in the two positions of a plate, and for the determination of the probable error of the measures. The probable error of the mean of the four measures of a star on a plate (6^m and 3^m images, each measured direct and reversed) is thus found to be $\pm 0''{\cdot}13$, and this is reduced to $\pm 0''{\cdot}11$ by applying the correction for personality.

Photographs of the Sun were obtained with the Dallmeyer photoheliograph of four inches aperture on 231 days. Of these, 496 have been selected for preservation, including sixteen with a double image of the Sun, taken to determine the position of the wires with reference to the parallel of declination. Photographs have also been received from India up to 1896 December 2, and from Mauritius up to 1896 November 2, leaving only two days—1896 February 14 and August 10—for which no photograph is available for measurement in the year ending with the date of the last Mauritius negative received.

The Greenwich photographs have been measured in duplicate up to the end of 1896, and the Indian and Mauritius photographs so far as they have been received. The areas and heliographic positions of the spots and faculæ have been computed throughout. The complete results for 1894 have been printed, and the results for 1895 have been passed for press up to April 4. Hitherto, little relief has been felt from the decline in the solar activity, which began to be noticeable in 1895, and which has been more evident in 1896; since the measures and reductions of the two very heavy years of maximum, 1893 and 1894, have only recently been completely disposed of. The mean daily spotted area of the Sun for 1895, expressed as usual in millionths of the visible hemisphere, is approximately 974, and for 1896, so far as the record is as yet complete, 524; as compared with 1464 for 1893, and 1282 for 1894, and with 1155 for 1883, the maximum year of the last cycle. On the three days 1896 April 15, 16, and 17, the Sun was free from spots; the first occasion upon which this has been the case since 1891 March 28.

Transit observations at contiguous stations in the front court, to determine the difference of longitude between them, have been continued on five nights with the instruments used in Paris-Greenwich longitude determinations. The observations, as well as those of 1895, are partly reduced.

The volume of *Greenwich Observations* for 1894 is printed with the exception of the Introduction, of which proofs have been received and returned to the printers. The transits and a large part of the zenith distances are printed for 1895. It is proposed from the beginning of 1897 to limit the printing of the details of the meridian observations to the observations of the Sun, Moon, planets, and fundamental stars (stars for clock-error, azimuth, and zenith point), and only to give results (mean R.A. and N.P.D. for each observation) for other stars.

The north wing of the new Physical Observatory is ready for occupation. The Lassell dome, which was dismounted by Messrs. Cooke last year, has been re-erected on the central octagon of the new building. Provision has been made in the Navy Estimates for commencing the building of the east and west wings, and thus completing the Physical Observatory.

Reference was made in the last report to the retirement of Mr. Criswick on 1896 January 31. Mr. Hollis was promoted to fill the vacancy thus occasioned in the staff of first-class assistants. In accordance with a rearrangement of the staff, which came into force in April, Mr. P. H. Cowell, M.A., Fellow of Trinity College, Cambridge, was appointed as the additional chief assistant to supervise the work in conjunction with Mr. Dyson, and Messrs. Davidson, Edney, Rendell, and Bowyer were added to the permanent staff as established computers.

It may be mentioned that the Astronomer Royal went to Japan, and Mr. Maunder and Mr. Crommelin to Norway, to observe the total eclipse of the Sun on August 9. No observations during totality were obtained at either station owing to cloud.

Royal Observatory, Edinburgh.

The mounting of the Grubb 24-inch reflector from Calton Hill in the west dome was begun in January. The driving clock has been fitted with an electric control by Messrs. Ritchie & Son, of Edinburgh. This clock is also arranged to drive the large four-barrel Cooke chronograph, which with the Fuess chronograph is mounted in the room under the west dome.

The clock-chamber in the base of the great pier of the east dome was found to be much affected by the moisture expelled from the cement during the process of hardening, but inconvenience from this source has been obviated by exposing within the chamber a large surface of calcium chloride in copper pans.

The time-service has been maintained under the care of Mr. Heath as in former years. This service comprises the working of the time-ball on the Nelson Monument, the firing of the time-gun at Edinburgh Castle and at Dundee, as well as the controlling of various clocks in the City of Edinburgh.

The regular meteorological record was begun at Blackford

Hill on 1896 January 1. Two rain-gauges are used, one on the grass, and the other on the roof of the main building; the thermometers (including dry and wet bulb, maximum and minimum) are mounted in a louvre screen near the grass rain-gauge. The cistern of the standard barometer, which is mounted in the barograph room, is 441 feet above sea-level. The King recording barograph, by Casella, has been in constant action since the beginning of the year. It was not until April that the recording anemometer was mounted on a tall iron lattice-pillar, erected above the porch of the detached observing house containing the 6-inch refractor. The continuous record of the velocity and direction of the wind began on July 17. Among the exceptionally high velocities recorded may be mentioned that of 68 miles per hour which occurred between 9 A.M. and noon on October 8. Abstracts of the meteorological observations are supplied each month to the Scottish Meteorological Society, and are inserted in the returns of the Registrar-General for Scotland. The rock thermometers at Calton Hill continue as formerly to be read once a week by one of the staff of the Royal Observatory.

On 1896 April 7 the new observatory at Blackford Hill was formally opened by Lord Balfour of Burleigh, Secretary for Scotland. The Earl of Crawford and Balcarres, to whose munificence the observatory is indebted for the fine collection of instruments from Dunecht as well as the exceedingly valuable Crawford Library, was present, and gave an interesting account of the founding of the new observatory.

Before the official opening, the efforts of the staff were directed towards mounting the instruments and putting them generally in order. The Dunecht meridian circle of 8·6 inches aperture, by Troughton & Simms, was mounted on its piers in the transit-house. Owing, however, to some defects in the roof-shutters, the instrument was afterwards removed from the Ys, and was not finally remounted until November, when the imperfections of the shutters had been satisfactorily remedied. The object-glass has been retouched, and the illuminations have been improved by the makers. Throughout the year the time-observations have been made with the 4-inch Cooke reversing transit.

In March the Council of the Royal Society of Edinburgh generously placed at Professor Copeland's disposal a grant for an expedition to Vadsö, in Finmark, to observe the total eclipse of the Sun on August 9, and preparations for it were begun in April immediately after the formal opening of the observatory. The equipment, which was wholly photographic, consisted of—

(1) A 40-foot telescope, with Dallmeyer lens of 4 inches aperture.
(2) A 6-inch telescope, with object-glass prism and camera, mounted equatorially, with driving clock.
(3) A camera with Dallmeyer lens of 4 inches aperture and

33 inches focal length, on a 4-inch Cooke equatorial stand, with driving clock.

(4) A camera with quartz lens of 1·8 inch aperture and Iceland spar prism, on the same stand as the 6-inch.

(5) A whole-plate camera, with Dallmeyer lens of $1\frac{1}{4}$ inch aperture and $10\frac{1}{2}$ inches focal length, also on the 6-inch stand.

The 40-foot tube was mounted on wooden trestles so as to point exactly to the place of the Sun at the middle of totality, while the Sun's motion was allowed for by driving the plate-carrier at exactly the required speed, on the plan so successfully adopted by Professor Schaeberle in 1893. The plates for this telescope measured 18 inches square. The driving clock was kindly lent by Lord McLaren.

All these instruments were mounted and carefully tested at Blackford Hill before being sent off, and the members of the expedition—viz. the Astronomer Royal for Scotland, Mr. Ramsay, and Engineer McPherson, along with Mr. Theodore B. Copeland, who kindly volunteered his services, sailed from Newcastle on July 18. Vadsö was reached on July 28, and on the same day several of the instruments were conveyed to the eclipse station on the Fossefjeld, $2\frac{1}{2}$ kilometres to the north of the town. By the day of the eclipse all the instruments were mounted in perfect working order, and only favourable weather was needed to ensure the success of the expedition. Unfortunately the sky was completely clouded at the time of totality; but some seconds afterwards the clouds partially cleared, and Mr. Ramsay succeeded in obtaining five plates of the crescent Sun with the 40-foot telescope. As was to be expected, however, no trace of corona appears on any of them; they distinctly show the irregularities on the Moon's limb. Mr. Theodore Copeland also obtained several plates of the crescent Sun with the Dallmeyer 4-inch camera. The expedition was much indebted to the Amtmand of Finmark for his aid in selecting the station, and to the Norwegian naval authorities, who placed a guard of sailors at their disposal.

The expedition party left Vadsö on August 13, and on arriving that day at Vardö had the satisfaction of greeting Dr. Nansen on his arrival in the *Windward*.

The Bifilar pendulum, presented by M. Antoine d'Abbadie, in 1894, was removed from Calton Hill in October 1895, and in the beginning of August 1896, was remounted at Blackford Hill, by Mr. Heath, who has charge of the instrument. A photographic apparatus, also presented by M. d'Abbadie, for continuously recording the position of the mirror, was at the same time placed in position, and has on the whole worked satisfactorily, although some difficulty was at first experienced in maintaining the uniform motion of the sensitive paper. Occasional interruptions of the record have occurred from this cause, but it is hoped that the

difficulty has now been overcome. The record shows several well marked deflections which have in part been identified with distant earthquakes; they are described in "Nature" of 1895 July 4 and 1896 November 5.

On all favourable occasions the 15-inch refractor has been employed in the observation of Comets and Minor Planets by Dr. Halm, who also redetermined the screw value of the micrometer. The following observations were secured :—

Comet 1895 IV.	... ...	4 observations
„ 1896 I.	... ...	25 „
„ 1896 III.	... ...	10 „
„ 1896 IV.	... ...	1 „
„ 1896 (Perrine, Nov. 2)	... ...	15 „
„ 1896 (Perrine, Dec. 8)	... ...	4 „
19 Minor Planets	... ...	70 „

These observations have all been reduced and the results communicated to the Royal Astronomical Society, or published in the *Astronomische Nachrichten*. Just before the end of the year the large Cooke spectroscope was attached to the 15-inch refractor, and a series of spectroscopic observations of Mars was begun. Dr. Halm has also made further observations for the latitude with the reversing transit in the prime vertical.

During the total eclipse of the moon on February 28, twenty photographs were secured by Mr. Ramsay with the 12-inch Browning reflector, while visual observations of disappearances and reappearances of craters were made by the other members of the staff. The occultation of the Pleiades on March 19 was also observed.

On November 13 four plates were exposed in the $1\frac{1}{4}$-inch camera mounted on the 4-inch equatorial stand, with the view of photographing the Leonid meteor tracks, but although several bright meteors were observed in the region to which the camera was directed, no trace of them appears on the plates.

During the year two circulars were issued containing elements and ephemerides of Comet *Perrine* (November 2) by Dr. Halm, and by Dr. Knopf, of Jena.

The new reduction of the right ascensions of the Henderson observations, in the hands of Mr. Heath and Dr. Halm, now appears to have removed the greater part of the systematic errors, which, in consequence of the imperfect knowledge of their physical causes and the provisional character of the earlier reductions, had seriously affected the positions of the catalogue. The accuracy of the computations made by the late Mr. Wallace has been proved by a thorough examination of the reductions to the mean of wires for the years 1834–36 and a comparison with the original note-books. On turning to the instrumental errors, however, it soon became apparent that the greatest care would

have to be given to this part of the new reductions. It is true that Henderson himself had grave doubts as to the stability of the instrument and suspected its liability to disturbance by change of temperature—indeed, he succeeded in bringing out a remarkable correspondence between the observed level readings and the indications of a thermometer slightly below the surface of the rock within the grounds of the Observatory. To his successor, Professor C. Piazzi Smyth, is due the great merit of extending these investigations to the azimuth, and of disclosing by the clearest reasoning combined with experiment the probable source of these variations. It is one of the most satisfactory results of the new reductions to have proved the correctness of Professor Smyth's conclusions by a totally different course of investigation.

But, notwithstanding the pains bestowed by Professor Smyth in applying these improved corrections to the observations, there still remained certain discrepancies incapable of satisfactory explanation, although their existence became known to the observers through the establishment of meridian marks to the north and south of the Observatory. At first sight it seemed probable to us that the clock might be taxed with these discordances, which were marked by a considerable difference in the clock errors day and night, but it soon became evident that this difference, amounting to more than one-tenth of a second, changed sign on the reversal of the instrument. The discordance arises almost suddenly at the beginning of the night, and then remains constant till the reappearance of daylight ; this places it almost beyond doubt that these well-marked changes of the collimation are connected with the mode of illumination, the matter being, however, further complicated by the fact brought out by the pole stars, that the effect varies somewhat with the zenith distance. The numerical value of this "illumination correction" is remarkably constant, and reduces the accidental errors of the transits so considerably that we may now expect very satisfactory results from these valuable observations. The years 1834 and 1835 have been completely reduced ; the resulting mean right ascensions show a remarkable freedom from systematic discordances, the agreement between the upper and lower culminations especially having been much improved. The instrumental errors for 1841–45 have been computed and tabulated, the data for these years being more complete than for the earlier period. The same work for the intervening years, 1837–40, is now being carried out. The clock stars for 1841 have been definitely reduced and the clock corrections derived.

Royal Observatory, Cape of Good Hope

Her Majesty's Astronomer was absent on leave from April 1 to December 1. During his visit to Europe he attended the meeting of the Permanent Committee of the Astrographic Con-

gress, held at Paris in May last. He also represented the observatories of the southern hemisphere at the Conference of Directors of National Ephemerides, held at Paris in the same month, on the question of adopting a uniform catalogue of fundamental stars and uniform constants in the National Ephemerides. As a delegate of the Cape Colony, he attended the International Congress, summoned by the Royal Society, to consider the question of the creation of a general subject catalogue of scientific literature.

Whilst in London, he reported officially to the Lords Commissioners of the Admiralty on the long-standing needs of the Cape Observatory in regard to an increase of staff and the supply of a meridian instrument (with a detached observatory) suitable for refined fundamental determinations. The Lords Commissioners of the Admiralty and of H.M. Treasury have favourably considered these proposals, and provision will be made for giving effect to them in the Navy Estimates for the financial year 1897–98.

Mr. Robert T. A. Innes has been temporarily appointed secretary and accountant ; no other changes have taken place in the staff.

The policy of pressing forward arrears of reduction has been maintained, and it has become possible to revert to a programme of activity in stellar meridian observation. Other departments are still cramped from want of staff. The annual results of meridian observations of stars for the years 1890 and 1891 have been placed in the hands of astronomers.

The annual results for 1892, 1893, 1894, and 1895, have been passed through press.

Volume ii. of *A Determination of the Solar Parallax and Mass of the Moon from Observations of Iris, Victoria, and Sappho, in the years* 1888 *and* 1889 is ready for distribution. This volume contains a description of the instruments and methods of observation, the details of the heliometer observations, Dr. Auwers' discussion of the meridian observations of the comparison stars, and convenient refraction tables for heliometer observations by Professor Harold Jacoby.

Volume i. of the same work has been completely passed through press, except the introduction and index, which are still in the printer's hands. This volume contains :—

Part 1. Discussion of the Heliometer triangulation of the *Victoria* comparison stars.

Part 2. Discussion of the heliometer observations of *Victoria*.

Part 3. Discussion of the heliometer observations of *Sappho*.

Part 4. Discussion of the heliometer observations of *Iris*.

Part 5. Discussion of the meridian observations of the same planets.

Part 6. A general discussion and combination of the results.

Of this work, part 4 is by Dr. Elkin ; part 5 by Dr. Auwers. An advance proof of part 6 was placed in the hands of members of the International Conference, which assembled at Paris on May 18 last.

The definitive values of the astronomical constants determined by the heliometer observations, and those recommended by the Conference for use in the National Ephemerides, are as follows :—

	From the Heliometer Observations.	Recommended by the Conference.
Mean Solar Parallax	$8''.802 \pm 0''.005$	$8''.80$
Mass of the Moon	$1 \div 81.702 \pm 0.094$	—
The constant of Nutation ...	$9''.207 \pm 0''.003$ (1)	$9''.21$
The constant of Aberration ...	$20''.467 \pm 0''.012$ (2)	$20''.47$

(1) Derived from the constant of precession and mass of the Moon.
(2) Derived from the solar parallax and Newcomb-Michelsen velocity of light.

Volume i. of the *Cape Photographic Durchmusterung*, containing the places of 152,000 stars, derived by Professor J. C. Kapteyn, from the Cape photographs, between the limits of declination $-19°$ and $-37°$ (both inclusive), has passed through press and is ready for distribution.

Volume ii. of the same work, containing the places of 158,000 stars, between the limits of declination $-38°$ and $-52°$ (both inclusive), is in course of printing.

An account of the Geodetic Survey of South Africa, executed by Colonel Morris, R.E., C.M.G., under the direction of H.M. Astronomer, with a re-reduction of Sir Thomas Maclear's triangulation, has been presented to the Cape Parliament, and distributed to astronomers and others interested in geodesy.

The manuscript of the Cape Ten-Year Catalogue of 3,007 stars for the equinox 1890, based on meridian observations from 1885 August 24 to the end of 1895, is practically completed, and, with the exception of the introduction, will be in the hands of the printer before this report is published.

The meridian observations (stellar and planetary) 1861-65, made under the direction of Sir Thomas Maclear, but which have remained unreduced to the present time, are completely reduced, and the manuscript (excepting the introduction) is ready for press.

The reduction of the remainder of Maclear's observations is in progress :—

The right ascensions are reduced to observed R.A. till 1866 December 31.

The clock errors are computed to 1867 May 12.

The N.P.D.'s are reduced to mean N.P.D. 1866 December 31.

The N.P.D.'s are reduced to observed N.P.D. 1868 June 1.

Duplicate independent computations of the star corrections for all stars (except *Nautical Almanac* and Polar stars) are computed for all the observations 1866-69, and one copy for those of 1870.

3,018 stars, to be employed as standard stars for the astrographic catalogue plates (ten stars per plate), have been selected for the zone $-40°$ to $-43°$, and the meridian work has been chiefly devoted to their observation.

Meridian observations have also been made of a list of 108 stars forwarded by Professor J. C. Kapteyn for special observation.

During 1896 the following transit circle observations have been obtained.

Meridian Transits	9,000
Determinations of Declination	8,677
,, ,, Collimation	98
,, ,, Level	327
,, ,, Azimuth	212
,, ,, Runs	315
,, ,, Nadir	311
,, ,, Flexure	52
Observations of the Meridian Mark Z.D.	45
,, ,, ,, ,, Az.	138

Of these observations :—

Apparent R.A. is computed to December 27.
,, ,, examined to December 20.
,, N.P.D. computed to December 26.
,, ,, examined to December 19.
Mean R.A. and N.P.D. examined to September 20.
Ledger prepared to August 20.
Star corrections computed to December 18.
,, ,, examined to December 6.

The following occultations of stars by the Moon have been observed :—

Predicted by the *N. A.* Office for the Cape.	Disappearance of Stars at the Bright Limb	2	
	Disappearance of Stars at the Dark Limb	16	
	Reappearance of Stars at the Bright Limb	1	
	Reappearance of Stars at the Dark Limb	13	
Not so predicted.	Disappearance of miscellaneous Stars, Dark Limb	44	
	Reappearance of miscellaneous Stars, Dark Limb	1	
	Daylight occultation of α Leonis D and R	2	by 1 observer
	Daylight occultation of Antares D and R	2	by 2 observers
	Total phenomena observed ...	81	

Of the occultations predicted by the Nautical Almanac Office four were observed by three observers, nine by two observers, nineteen by one observer. The occultations of miscellaneous stars were observed chiefly by one observer—Mr. Innes.

The same observer has devoted himself with great success to a search for southern double stars, and the examination of stars which, in course of preparation of the Cape Photographic Durchmusterung, have been suspected by Professor Kapteyn of variability.

With the 7-inch equatorial Mr. Innes has found during the year no less than 104 new double stars, of which forty-five are of distance 0·″6 to 1″, thirty-one of 1″ to 2″, and seven have very faint companions exceeding 5″ distance, the remainder being within the limits 2″ to 5″. The duplicity of three other stars has been detected by the transit circle observers. A list of these stars for communication to the society is attached.

Over 300 stars, to which attention has been drawn by Professor Kapteyn, have been regularly observed for variability, mostly with negative results ; but many of these, in addition to the following variables already found, are still under observation.

		h	1875. h	m	s	°	′			
1	Z.C.	8·4821	8	59	35	−24	35·5	Innes	Mag.*	
2	O.A.	10288	12	54	7	−19	46·7	,,	,,	9·0 to 9·9
3	Z.C.	13h·2483	13	41	2	−36	14·2	,,	,,	8·1 ,, 10·5
4	Gould	19229	14	4	22	−28	17·6	,,	,,	9·0 ,, under 12·5
5	Z.C.	15h·3719	15	52	56	−29	33·9	,,	,,	9·0 ,, 10·5
6	Z.C.	15·4006	15	57	8	−23	45·2	,,	,,	8·0 ,, 10
7	Z.C.	16·2278	16	32	36	−32	7·9	,,	,,	8·2 ,, 9·4 deep red
8	O.A.	16813	21	19	19	−30	23·4	Finlay	,,	8·0 ,, under 12·5

The discovery of Nos. 3, 6, 7, and 8 has been announced, *Ast. Nach.* 3,389.
No. 4 is also in Thome's list of suspected variables.
From Thome's list of suspected variables there was also found

9	Th.	−33°·185	0	27	1	−33°·34	Innes	Mag.	10·2 to under 12·5

With the Astrographic telescope the following work has been accomplished :—

	No. of Plates exposed.	Exposures. No.	Exposures. Duration.
Catalogue plates	55	165	6m 3m 20s
Chart plates (even degrees)	237	237	60m
Chart plates (uneven degrees, triple exposure)	7	17	30m each image
Standard areas	37	111	6m 3m 20s
Comparison of standard areas with south pole area	8	54	6m 3m 20s
Plates for light curve of R Velorum	23	94	6m
Stars suspected of variability in Kapteyn's discussion of the Cape Phot. Durchmusterung	133	379	6m
The cluster in Toucan	9	9	5m to 2h
Trails, &c.	10	22	
	519	1088	

* Proved variable 1896 April 19, May 20, 10m·2, invisible May 26, but was published variable in Harvard Circular, No. 7, June 5.

The photographs of the cluster in *Toucan* have been made at the request of Dr. Alexis Hansky, of the Pulkowa Observatory.

The catalogue plates are now all taken, but investigations under the measuring machine have led to some repetitions—a few of these on account of faulty images, but generally on account of paucity of stars.

No provision has yet been made for the regular measurement of the catalogue plates, but 26 catalogue plates (5,743 stars) have been measured in course of the year as opportunity offered.

The number of stars per plate has varied from 53 on the plate $-42° 4^h 40^m$, to 780 on the plate $-42° 8^h 10^m$.

The coordinates and diameters of the star-discs on every plate have been measured independently by two observers.

A more rapid and yet sufficiently accurate method of measurement is now under consideration and arrangement. Provision will be made for carrying on the work of measuring the catalogue plates on a much greater scale after 1897 April.

Of the 237 chart plates exposed, 169 have been passed as satisfactory; this leaves 84 of the even degree, single image plates yet to be done. Of the seven uneven degree triple exposure plates taken, two were stopped by cloud after one image had been impressed.

The triple exposed plates are extremely satisfactory, as they render the existence or otherwise of a star a matter of perfect certainty. The guiding telescope has been furnished with three spider webs in the common focus of the object-glass and eyepiece. These webs form a small equilateral triangle (sides about 8″), and the guiding star is placed successively in the three angles of this triangle.

The 36-foot dome of the McClean Observatory, by T. Cooke & Sons, of York, has been erected by one of the foremen of the firm (Mr. Selby) sent out for the purpose. The dome is a thoroughly satisfactory piece of work, excellent in design as well as workmanship, and easy and convenient in use.

The observatory building itself cannot be quite completed till the heavy castings of the telescope stand have been placed *in situ*.

Unexpected delay has occurred in the completion of the telescope, but when H.M. Astronomer visited Dublin in November last Sir Howard Grubb promised that the instrument would be completed in four months from the time when the base castings (expected immediately) arrived. The prisms and object-glasses for the star spectroscope have been received from Mr. Brashear, the working drawings have been completed, and the construction of the instrument has been commenced by the Cambridge Scientific Instrument Company. The rising floor with its hydraulic machinery reached the Cape in October, and its erection was commenced immediately on Dr. Gill's arrival from England on December 1; considerable progress has been made in this work.

It is expected that before the end of 1897 the McClean telescope and observatory will be in full working order.

The time-signal service has been regularly maintained. The meteorological observations made at the observatory in 1895 have been communicated for publication to the Cape Meteorological Commission.

Cambridge Observatory.

The *Catalogue of Zone Stars* is now printed, and only requires the Introduction and Appendix to complete the volume.

It gives the places of 14,441 stars, with a few additional which will appear in the Appendix. Each of these has been observed, on an average, about four times.

A discussion of all the stars observed seven times and upwards, and a few in the first hour of right ascension which had been observed five or six times, taken indiscriminately, two only being omitted which gave clear indication of proper motion—in all, 945 places deduced from 7,461 observations—gives for the probable error of one observation

$$\text{in R.A. } \pm 0^{s}\cdot 06608$$
$$\text{in Decl. } \pm 0''\cdot 5079.$$

Guided chiefly by the letters affixed in the *Durchmusterung*, about 9,000 places in this catalogue have been compared with the older catalogues. This comparison has brought to light not a few interesting and decided cases of proper motion. A list of these cases has been drawn up for re-observation, and a good number have been already observed.

The manuscript for an enlarged catalogue, which is to contain the result from each individual observation of each star, has been carefully revised, and the first ten hours are copied for the press.

The Newall Telescope, Cambridge Observatory.

The Newall Telescope has been used for observations on 112 nights in the course of the year 1896, this number being the smallest in any year since the instrument was set up at Cambridge. The "seeing" has been unusually poor, especially in the latter half of the year.

Almost the whole year's work has been devoted to spectroscopic work with the Bruce Spectroscope. A description of this instrument has been published in the *Monthly Notices*, vol. lvi. p. 98. The only alteration in the arrangement there described has been the substitution of a new correcting lens made of denser flint, by Messrs. Cooke & Sons. This lens gives very satisfactory results, with increased density and extension in the photographic spectra on the ultra-violet side of $H\gamma$.

The investigations undertaken in the early part of the year were chiefly determinations of velocity in the line of sight in the case of various bright stars. Iron, helium, and hydrogen have been used for comparison spectra, with a view of comparing the results obtained with the classical work of Dr. Vogel, in which hydrogen was used. The velocities deduced from the discussion of the photographs showed signs of a more or less systematic difference from the Potsdam results. It is well known that the greatest difficulty in determination of velocity in the line of sight is the arrangement of the comparison spectrum. Accordingly the greatest care was bestowed at the outset on the adjustment of the apparatus provided in the Bruce Spectroscope, in order that the position of the comparison spectrum on the plate should be irrevocably set by the instrument, and should not be in any way at the arbitrary disposal of the observer ; but it appears that latterly a displacement has occurred to which the discrepancies from the Potsdam results must in part be referred, and the exact cause is still to be explained.

The troublesome search for a comparison spectrum which shall be above suspicion has involved a great deal of what may be described as underground work, and has in great measure thrown back the astronomical investigations. But for the guidance of other workers, who may wish for information relating to the spectra and not relating to the velocities of the stars, it may be of interest to state that the spectra of the following objects have been specially studied :—

α Aquilæ	γ Cygni	β Orionis
α Aurigæ	α Geminorum	γ Orionis
α Boötis	β Geminorum	α Pegasi
β Cassiopeiæ	α Leonis	α Persei
γ Cassiopeiæ	α Lyræ	Jupiter
α Cygni	α Orionis	Venus

Dunsink Observatory.

For two months in the early part of the year observations with the meridian circle were discontinued in order to complete the work of preparing a catalogue for the press. Early in March this was accomplished, and in July the catalogue, forming Part vii. of *The Astronomical Observations and Researches made at Dunsink*, was published and distributed. This contains the separate observations of 717 stars, and their mean places for the epoch 1890. The probable error of these places as deduced from the separate results for all those stars which were observed more than three times is for a single observation—

in R.A. $\pm 0^{s}\cdot037$

and

in Decl. $\pm 0''\cdot505$.

In bringing this work to a close, it was intended to discontinue meridian observations for the present, in order to carry on the photographic work with the "Roberts" equatorial more vigorously.

Several things have, however, conspired to alter this intention, and during the year the main observing strength has still been devoted to observations with the meridian circle. The details of the reduction of measurements on photographic plates for the detection of stellar parallax had not yet been completely worked out, and some points in the management of the telescope remained to be experimentally tested. It seemed well, therefore, to proceed with the observations of the Zodiacal stars required by Dr. Downing for use in the *Nautical Almanac*, and of some other stars, including some of those in Part vii. of which further observations seemed desirable.

During the year there have been in all 6,321 observations made with the meridian circle. This number includes 169 observations of the error of collimation of the instrument, 176 of the level error, 148 of the nadir point (by reflexion), and 29 of the error of runs of the microscopes. For determining the error of azimuth 101 transits of polar stars have been observed; for determining the error of the Dent sidereal clock 531 transits of standard stars have been recorded; and for the equator point of the circle 443 observations of the zenith distance of these stars have been made. The observations of stars on the working list amount in R.A. to 2,355, and in Decl. to 2,369, which have all been reduced to apparent place up to the date October 6.

With the "Roberts" equatorial 77 photographs have been taken, representing 109 exposures of various lengths. The objects photographed include the great cluster in *Perseus* (G. C. 512 and 521), *Præsepe* and M 13 (*Herculis*); the nebula H. IV. 37, the annular nebula in *Lyra*, and the great nebulæ in *Andromeda* and *Orion*, and a number of stars, including η *Cassiopeiæ*, η *Ursæ Majoris*, ϵ *Lyræ*, and others.

Photographs were also taken of Comet *b* 1896 on the nights of April 29 and 30 and May 2 and 8.

Some time has been spent in experimenting on a method of allowing for the inequality which the motion of a star undergoes in consequence of refraction, and very satisfactory results have been attained by employing a mercury compensation pendulum, the rate of which can be accurately controlled and adjusted to the rate of movement of a star by altering the weights on the shelf of the pendulum from time to time during an exposure, according to the formula given in a paper published in the *Monthly Notices* for December.

The "South" equatorial was employed for observing the transits of the "garnet" spot on *Jupiter* on thirteen nights in February and March. These observations were employed for determining the period of rotation of this marking, and the result was published in the *Proceedings of the Royal Dublin Society*, vol. viii. part v. No. 49.

Observations of the *Leonids* were made on the mornings of November 14 and 15 (civil time) and an attempt, which was unfortunately unsuccessful, was made to obtain photographs of the trails of some of them. The results of these observations are published in the *Monthly Notices* for December.

The preparations for observing the eclipse of August 8 and the expedition to Vadsö, in which the director took part, necessarily occupied time, and interfered with more productive observations for some weeks in August.

The time service to Dublin has been maintained as in former years ; and on the first Saturday of each month the Observatory has been open to visitors, and the 12-inch "South" refractor placed at their disposal.

Durham Observatory.

Regular meteorological observations have been taken and the usual reports issued, but persistent bad weather has made regular astronomical observations almost impossible.

The curators are making arrangements for setting up an Almucantar to take the place of the old transit circle. Experiments have been made to ascertain the effect of wind upon it. It is hoped that the instrument may be set up and in use before the next report.

The library is being rearranged, overhauled, and catalogued.

City Observatory, Calton Hill, Edinburgh.

In accordance with an agreement entered into between the authorities of the Crown and the Corporation of Edinburgh, the buildings and grounds of the old Royal Observatory were formally handed over to the Town Council at the beginning of last year. Since then the work of reconstructing the observatory has been rapidly proceeded with. The main buildings were repaired and painted, and several alterations and improvements made, particularly in connection with the central dome and photographic rooms. The alterations in this dome were rendered necessary for the efficient working of the new 6-inch Cooke visual and photographic equatorial, which, along with a large spectroscope and chronograph, was presented to the observatory early in the year by Mr. W. McEwan, M.P.

The main buildings also contain the mural circle and 6-inch transit instrument, which were kindly left on permanent loan by the Crown authorities, on the recommendation of the Astronomer Royal for Scotland. Both of these instruments are in excellent working condition.

The McEwan barrel chronograph by Messrs. Cooke & Sons,

and a ribbon chronograph, have been fitted up in the transit-room, and have since been constantly employed in observations for time.

For the accommodation of the other instruments belonging to the Corporation, several new buildings had to be erected in the grounds. The first of these is a large octagonal stone house, 38 feet in diameter, with dome, by Sir Howard Grubb, for the accommodation of the large refractor of nearly 22 inches aperture and 30 feet focal length. The dome, which has just been completed, has turned out to be a great success. The covering is of paper, $\frac{3}{8}$ of an inch in thickness, riveted on to angled iron ribs. The revolving apparatus of the dome, which works most efficiently, consists of the usual "live ring," and contains eighteen rollers, each $17\frac{1}{2}$ inches in diameter. Notwithstanding the great weight of the structure, the workmanship is so perfect that a tangential pressure of not more than five pounds is sufficient to move the dome. The second building is a drum dome 18 feet in diameter, containing a reflecting equatorial telescope of 13 inches aperture, the gift of Mr. R. Cox, M.P.; and the third building, which is still in the workmen's hands, is a paper-covered dome, 18 feet in diameter, and which is intended to shelter the equatorial reflecting telescope of 13 inches aperture, kindly presented to the observatory by Lord Crawford and the Astronomer Royal for Scotland. There is also a small transit house with 3-inch transit circle for the use of students. In connection with these various buildings there is being introduced a system of sidereal clocks governed by the standard clock of the observatory; while in connection with the standard mean time clock, and controlled by it, there will soon be in operation several mean time clocks distributed throughout the city.

Glasgow University Observatory.

The work done with the transit circle was preliminary to the observations of the rectangular co-ordinates of the principal pole stars, and of the three stars which are nearest to the pole. After the new micrometer by Troughton & Simms had arrived in February, the screw value was determined, and the progressive errors of the collimation screw were derived. The screw is almost perfect, the range of the corrections not exceeding 0·008 on 40 revolutions.

A series of observations of the division errors of the Ertel circle having shown that they were influenced by systematic errors, it was found that the plane of the end of the axis, and that of the end-thrust, were not at right angles to the axis, thus causing the circle to alter its distance from the microscopes; to obviate this, a knob was then soldered to the end-thrust at its centre. Great care was bestowed on the adjustment of the

microscopes in a plane which passes through the axis of rotation. The telescope was directed towards one of the collimators, the microscopes were read, and the readings were repeated after the circle had been moved 0·02 inch away from the microscopes.

For the determination of the division errors, the same arrangement was adopted that was employed by C. A. F. Peters in his investigation of the errors of the Pulkowa vertical circle by Ertel. There was, however, this difference, that the errors of division of every fifth degree were determined with equal precision, the intervals measured being 90°, 75°, 15°, 70°, 20°, 60°, 30°. For the mean of four microscopes the corrections do not exceed 0″·5.

The spectroscope was mounted on the twenty-inch Breadalbane reflector, but it has not yet been used on celestial objects, because it was found, after careful examination, that the prism should be sent away to be re-annealed.

An attempt was made to photograph the *Leonid* meteors on November 13. A plate was exposed in the focus of the 20-inch reflector which was directed towards the radiant point, and a camera of $1\frac{1}{2}$-inch aperture and 8-inch focal length, was also mounted at the eye-end of the reflector. During the greater part of the night the sky was overcast, and although one bright meteor did pass the field, there was no trace of it on the plates. Next year a camera with a lantern lens will be tried.

The time-service and the extensive meteorological work have been carried on as in former years.

Liverpool Observatory.

The work of the Observatory for the last year has mainly followed the lines indicated in the last report. The testing of chronometers and other scientific apparatus deposited by the public, and the determination and distribution of time form much of the routine work of the Observatory. The errors of the transit instrument, which had become inconveniently large, have been reduced by rubbing down the Y plates in a manner suggested by Mr. Simms. The method was perfectly successful, and the errors remained small throughout the autumn. They have since shown a tendency to increase, and the greater part of that increase occurred immediately after a slight shock of earthquake on December 17. Slight improvements have been made in the chronographic registry apparatus. No alterations have been made in the other astronomical instruments.

The comet observations of 1895 have been published in the *Monthly Notices*, and those for 1896 will shortly be submitted to the Society. The observations of the diameters of the larger planets, with different micrometers, and under different conditions of illumination, have been continued from time to time,but the observations have been much interrupted by bad weather.

The report of the Director to the Mersey Dock and Harbour Board, consisting mainly of meteorological observations, has been printed and circulated during the year. Considerable attention has been given to improved meteorological observations, and a new anemometer was erected in the summer.

Courses of lectures have been given regularly in connection with the classes at University College, Liverpool, and opportunities have been given to the students for practical work with the transit instrument and equatorial. These classes have been fairly well attended.

Radcliffe Observatory, Oxford.

The work at the Observatory during the year 1896 has included the following :—

The Sun and Moon have been observed with the transit circle at every available opportunity ; seven observations of Comet Swift (1896 April 13) and one of Perrine (1896 Dec. 8) have been secured with this instrument ; and the positions of several stars which could not be found in recent catalogues, but which were required for the reduction of the comet observations, have also been obtained with the transit circle.

The observation of a zone of stars to the north of the equator has been commenced during the year. This work is in continuation of that of the Radcliffe Catalogue for 1890 and the Cape Catalogue, 1880.

The Working Catalogue also includes a selection from a list of 834 zodiacal stars published as an appendix to the *Nautical Almanac* for 1897, observations of which are requested for the use of the *N. A.* office.

As the pivot error of the Radcliffe transit circle had not hitherto been satisfactorily determined, an interference apparatus, described by M. Hamy in the *Comptes Rendus*, was constructed and used for testing the form of the pivots. This apparatus is exceedingly delicate in its test, and showed that any existing errors were so small as to be practically insensible (see *Monthly Notices*, 1896 March).

An improved method of illuminating the wires of the transit-circle eyepiece has also been devised and mounted during the year.

The Barclay equatorial has been chiefly employed in the observation of comets :—

Perrine (1895 November 16)	on 1 night
Perrine-Lamp (1896 February 13)	„ 8 nights
Swift (1896 April 13)	„ 12 „
Sperra (1896 August 31)	„ 1 night
Brooks (1889 V.)	„ 1 „
Perrine (1896 November 2)	„ 6 nights
Perrine (1896 December 8)	„ 2 „

Besides these, rough positions were obtained, when the faintness of the object, cloud, or other adverse conditions prevented a perfectly satisfactory observation being made :—

Swift (1896 April 13)	on 2 nights
Giacobini (1896 September 4)	„ 3 „
Sperra (1896 August 31)	„ 1 night
Perrine (1896 November 2)	„ 2 nights

Searches for comets were made on eighteen nights, when the observers failed to pick them up.

The Barclay telescope has also been used for the examination of the great nebula of *Andromeda* ; for the determination of the position of nebula Herschel 544 ; a cluster of stars (R.A. $19^h\ 0^m$, N.P.D. 99° 30′) ; comparison stars for comets ; and for the estimation of the magnitudes of a deep-red star and some suspected variables.

The eclipse of *Jupiter's* fourth satellite (disappearance) was observed on April 13 by three observers ; the occultation of *Jupiter* by the Moon was seen by two observers, but the objects were very low and the definition poor.

The total eclipse of the Sun was successfully observed by Mr. Stone at Novaya Zemlya. The details of the expedition and subsequent discussion of the observations have been already communicated to the Society.

Tables have been prepared for facilitating the correction of the reduction of apparent places of stars to mean places for the interval between the time of observation and the nearest Greenwich mean midnight.

The meteorological observations and automatic registrations have been maintained as usual.

A Callendar-Griffiths temperature bridge and four platinum thermometers have been recently procured from the Cambridge Scientific Instrument Co., and the thermometers have been sunk to the respective distances of 6 in., 1 ft. 6 in., 3 ft. 6 in., and 5 ft. 10 in. below the surface of the ground.

The volume containing the Radcliffe observations made in the years 1888–89 was distributed during the spring of the year.

University Observatory, Oxford.

During the year 1896 attention has been paid chiefly to the measurement and reduction of the Catalogue plates for the Astrographic Chart. It seems clear that this is the most pressing part of the work, and the taking of new plates has not been pushed forward, so that more time might be given to the measurement and reduction of those already taken. The plan of procedure may now be regarded as settled and the work is proceeding rapidly. Application was made to the Government

Grant Committee in 1895 January for 150*l.* for the expenses of this work for one year, with the intimation that if the application were favourably considered it would be repeated for five years altogether. The first application was granted, and four boy computers are now engaged on the work; two micrometers are at present in use, and two more have been ordered from Messrs. Troughton & Simms, when it became clear that these could be used with advantage. This labour and apparatus has only, however, been available during a part of the year, which may be estimated as equivalent to one half.

The plates are each measured twice by the same observer, being rotated 180° in position-angle between the two measurements. The numbers expressing the rectangular co-ordinates of the stars in the second position are thus the arithmetical complements of those in the first. They are made comparable with the first by subtracting them from 26·000. A second computer performs this subtraction independently and compares the measures in the two positions. In this way he finds three kinds of discordances :—

1. Stars measured on the first occasion (D) and omitted on the second (R).

2. Stars measured on the second occasion (R) and omitted on the first (D).

3. Discordances of measurement, *i.e.* differences between the measures exceeding 0·005 of a réseau interval, or 1″·5. Forming a list of these, he calls upon the measurer for measures R of the first set, measures D of the second, and remeasures R and D of the third. This affords a valuable and practically complete check upon the results. The normal differences also show the "error of bisection" in measurement, which is eliminated from the mean of the two sets. The following tabular statement (of a portion of the work only) gives an idea of the quantities involved :—

Measurer.	Total No. of Stars.	No. Missed in R.	No. Missed in D.	No. of Discordant Measures.	Twice Error of Bisection (D−R) x	y
					″	″
B	1968	91	193	114	+0·33	+0·24
F	2027	116	118	166	−0·12	+0·30
H	2128	114	125	233	−0·03	+0·09
C	2044	103	84	155	−0·33	0·00

Assuming that the "error of bisection" is eliminated by taking the mean of the two measures, we can proceed to determine the systematic error in R.A., depending on the magnitude of the star for the Cambridge meridian observations, which supply the fundamental stars of reference for these plates; and this discussion will shortly be undertaken.

The number of catalogue plates taken during the year is 168, bringing up the total to 777. In the "direct" or "D" position 135

plates (containing 22,601 stars) have been measured, and 80 (containing 11,652 stars) in the "R" position. Two thirds of the measuring has been accomplished since August 29, when two micrometers became continuously available. One of the micrometers was taken by the Director to Paris for exhibition to members of the Comité Permanent at its meeting in May, and was left at the Paris Observatory for experiment, by request. It had, however, been somewhat shaken by the journey, and did not perform so well as it might have done. By request of the Comité, the Director measured some stars on one of the Paris photographs, and the Comité was favourably impressed with the rapidity with which these measures could be made.

The advance proofs of the remainder of the Cambridge Catalogue ($5^h - 24^h$) have been received from Sir Robert Ball, and the places brought up from 1875·0 to 1900·0. A complete copy of the places for 1900·0 (14,500 stars) has been furnished to the Cambridge Observatory, by request.

Tables for converting the R.A. and Dec. of these stars into standard coordinates for zones $+25°$ to $+31°$ have been made, and the conversion of the stars in zone $+26°$ is completed and nearly examined, while that of stars for zone $+27°$ is well advanced. The zone $+25°$ is that of overlap between Cambridge and Berlin. 2,224 stars in the Berlin catalogue of declination greater than $+23°\ 45'$ have been brought up to 1900·0.

An effort will be made to complete the measurement and reduction of zones $+26°$ and $+27°$ before the end of 1897.

Lectures on elementary mathematical astronomy were delivered in the Hilary and Michaelmas terms. Several students have worked at practical astronomy in the Observatory.

The Director went to Japan during the summer for observation of the Total Solar Eclipse of August 9; but clouds prevented observations.

Temple Observatory, Rugby.

The usual educational work has been carried on during the past year at this Observatory, and an increased interest has been shown on the part of the boys.

The work of measuring double stars has been continued as usual, and a considerable number have been observed.

Some microphotography has also been done by Mr. K. Lucas at this Observatory.

Stonyhurst College Observatory.

The work of this Observatory during the past year has been the same as described in *Monthly Notices*, Feb. 7, 1896. The continuous photographic records of meteorological and magnetic changes have been broken only by occasional troubles with the gas supply.

The vertical force needle of the magnetographs was, however, dismounted between March 10 and June 23, and some experiments were made with the hope of improving its behaviour, but without any satisfactory results. The agate knife-edge and rest seem to be as good as can be made ; but we are unable to place confidence in any numerical measures given by it, because it is apt to move by jerks, and does not safely return to its original position after deflection by another magnet.

About 130 photographs of the H–K region of the solar spectrum have been obtained with integrated solar light. These have not been fully examined yet, but, so far, it seems probable that the fine reversal of K has been either non-existent or very feeble.

Over 350 plates have been exposed for stellar spectra. These include some trials with the very small dispersion of a single half prism for the sole purpose of finding the condition of the K line in a star spectrum. The results of these experiments have not been very satisfactory ; the definition is only such as to differentiate between a very strong, a medium, and a thin line ; but it cannot decide upon the absence of the line. It does, however, show the line in stars to the 6th magnitude.

Dr. Common's Observatory.

Experiments with the oblique Cassegrain telescope were discontinued, and the direct Cassegrain form has been tried. The 5-foot mirror (C) has been reground under new conditions, with great improvement to the figure ; two 30-inch concave mirrors for Cassegrain telescopes have been made, and two 16-inch and two 18-inch convexes for the 5-foot.

Some time was spent in preparations for observing the Total Solar Eclipse of August 9, and in going to Vadsö to observe it.

The 5-foot telescope is at present fitted up with a 30-inch Cassegrain telescope inside, but the bad weather during the winter has prevented any regular work.

The experiments referred to in the report for 1891, on the comparative reflective powers of silvered glass and speculum metal, &c., which were never completed, have been taken up again.

Mr. E. Crossley's Observatory, Bermerside, Halifax.

The work at this Observatory during the year 1896 differed little from that of previous years. Much time was devoted to observations of the planet *Jupiter*, and the results have already appeared in the Society's *Monthly Notices*. The usual meteorological observations were made, and monthly or annual summaries sent to the Registrar General, Mr. G. J. Symons, and others.

In June the old $9\frac{1}{2}$-inch object-glass was replaced by one of Messrs. Cooke's new triple lenses of 9-inch aperture and 152 inches focal length. It has not yet been tested photographically, but in other respects has answered our expectations to the fullest extent.

Dr. Huggins's Observatory, Upper Tulse Hill.

The new spectroscopes which were in course of construction for the ultra-violet region have been completed during the year, and have been put into a state of adjustment. A series of star photographs has been begun with special reference to the region in the ultra-violet at and beyond which the absorption of glass comes in seriously. This work, together with some special lines of research, is being carried on whenever the weather is favourable. Unfortunately, the continuance of bad weather since November has been all but uninterrupted.

Rousdon Observatory, Lyme Regis. (*Mr. C. E. Peek's.*)

The building and equipment of the Observatory has been maintained in its usual order, and the weather has on the whole been very favourable for astronomical observation; 170 nights were available for work. The 6·4-inch equatorial refractor has been kept at the regular observation of long-period variable stars on the same lines as during the previous ten years, and 535 determinations of magnitudes have been made. Twenty-three maxima and eighteen minima have been observed. Twenty-five long-period variables are under regular observation, and being mostly circumpolar, the light variations are continuously recorded.

Transits of stars for time have been observed as often as required, and the sidereal clock has maintained a very steady rate.

The occultation of *Jupiter* and his satellites was observed on June 14 under very favourable conditions.

Dr. Isaac Roberts's Observatory, Crowborough Hill, Sussex.

The opportunities for taking photographs with long exposures of the plates have during the past year been comparatively few in number, and one is tempted to reiterate the assertion that the climate, for clear skies at nights, is in this country deteriorating.

The work done here during last year will be estimated by the following list of photographs which have been taken, and it is

given in continuation of similar lists which have been published in the *Monthly Notices*, vol. lvi. pp. 239–241, and in previous years. The photographs are available for reference, as also are those taken in former years.

	R.A. h m	Decl. ° ′	Expos. m
Cl. H VI. 35 Cassiopeiæ	0 25	+60 56	60
Great Nebula in Andromeda ...	0 36	+40 30	4h
Neb. H V. 25 Ceti	0 41	−12 27	90 and 2h 55m
Nebula in Cassiopeia	0 47	+56 2	2h 54m
Neb. H II. 215 Andromedæ ...	1 1	+31 57	90
Neb. H I. 54 Andromedæ	1 2	+39 5	86
Neb. H I. 157 Trianguli	1 42	+26 55	90 and 2h 55m
Neb. H I. 62 Ceti	1 46	−10 14	90
Neb. H III. 162 Trianguli	2 37	+31 59	90
Nebulæ in the Pleiades	3 40	+23 46	92 and 2h 50m
Nebula in Perseus	3 56	+36 8	90
Great Nebula in Orion	5 30	− 5 27	90
Neb. near ζ Orionis	5 35	− 2 0	90
Cl. H VIII. 33 Monocerotis ...	7 3	−10 29	60
Cl. M. 48 Monocerotis	8 8	− 1 38	60
Cl. Præsepe Cancri	8 34	+20 19	80
Neb. H I. 3 Sextantis	10 8	+ 3 57	90
Neb. H I. 266 Ursæ Majoris ...	10 15	+57 28	90
Neb. *h* 705 Leonis	10 18	+13 5	90
Neb. H I. 267–8 Ursæ Majoris ...	10 49	+57 36	50
Neb, H I. 220 Ursæ Majoris ...	11 5	+53 57	90
Neb. H I. 270–1 Ursæ Majoris ...	11 12	+58 58	90
Neb. H I. 226 Ursæ Majoris ...	11 15	+53 46	90 and 2h 49m
Neb. H I. 252–3 Ursæ Majoris ...	11 56	+62 36	90
Neb. H I. 224, 206 Ursæ Majoris ...	12 0	+51 2	65 and 2h 50m
Neb. M. 98 & 99 Virginis	12 11	+15 15	2h 57m
Neb. M. 100 Comæ	12 17	+16 24	2h 55m
Nebulæ in Virgo	12 30	+13 0	90
Neb. H V. 24 Comæ	12 31	+26 34	2h 53m
Neb. M. 64 Comæ	12 51	+22 15	2h 56m
Neb. H I. 96–7 Canum Venatic. ...	13 7	+37 23	62
Neb. M. 64 Canum Venaticorum ...	13 11	+42 35	2h 55m
Neb. M. 51 Canum Venaticorum ...	13 25	+47 45	2h 25m
Neb. H I. 255–6 Draconis	13 46	+60 53	90
Neb. H I. 237 Draconis	14 29	+58 23	90

	R.A. h m	Decl. ° ′	Expos. m
Neb. H I. 189 Boötis ...	14 29	+49 56	90
Neb. H II. 756 Boötis ...	14 55	+54 19	90
Neb. H II. 751–2 Boötis ...	15 2	+20 0	65
Neb. H II. 757–9 Draconis ...	15 13	+56 43	62
Neb. H VI. 41 Draconis ...	17 33	+75 48	2h
Cl. M. 25 Sagittarii	18 25	−19 1	60
Cl. M. 11 Antinoi	18 46	− 6 24	90
Hind's Neb. in Aquila ...	19 6	+ 0 52	90
Cl. H VI. 38 Aquilæ	19 26	+ 9 0	2h
"Dumb-bell" Neb. in Vulpecula	19 55	+22 25	2h 55m
Neb. H IV. 76 Cephei ...	20 33	+59 47	2h 55m
Neb. H V. 15 Cygni	20 42	+30 20	2h 18m
Neb. H V. 14 Cygni	20 52	+31 4	2h 31m and 2h 55m
Neb. H V. 37 Cygni	20 55	+43 55	90 and 2h 55m
Cl. H VI. 24 Cygni	21 9	+42 3	90
Cl. H VI. 29 Cephei	22 11	+53 48	43
Neb. H I. 104 Aquarii ...	23 13	− 9 3	90 and 2h 53m
Neb. H I. 110–111 Aquarii ...	23 34	−13 12	62

Mr. Wilson's Observatory, Daramona, Streete, co. Westmeath.

During the past year an optical method has been tried for detecting any shift that may take place in the 24-inch mirror while it is being used for stellar photography. The apparatus seems to work very well.

Professor Minchin again used the 24-inch to determine the electromotive force of the light of some of the stars with his photo-electric cells, the results being published in the *Proceedings* of the Royal Society.

The radiation of heat from sun-spots has been continued whenever spots of suitable size have been seen on the disc.

A series of experiments have also been carried out on Solar Radiation with Stewart's Actinometer for a committee of the British Association.

An investigation in conjunction with Professor G. F. Fitzgerald has been made in order to determine if carbon is raised to its boiling-point in the electric arc.

The results have been published in the *Proceedings* of the Royal Society, and seem to show that carbon may possibly exist in the Sun's photosphere in the solid form.

Adelaide Observatory.

During the past year the Observatory has been very short-handed, and the work has not only had to be curtailed, but has fallen somewhat into arrears. At the end of January Mr. W. E. Cooke, M.A., the first assistant, left Adelaide to take charge of the new Observatory to be established at Perth, and on July 25, the establishment sustained a great loss in the death of the third assistant, Mr. E. P. Sells, whose health had long been failing. Mr. R. F. Griffiths, second assistant, succeeded Mr. Cooke, but there are still two vacancies, one of which will be filled by the appointment of Mr. S. W. Chettle, Mr. W. R. Wilson succeeding Mr. Sells as second assistant. The actual working staff in 1896 consisted of Mr. R. F. Griffiths, Mr. W. R. Wilson, and Miss M. E. Greayer.

With the transit circle the only regular work undertaken has been the continuation of the observation of stars for the Melbourne Photographic Durchmusterung; 788 observations of R.A. and a similar number of observations of N.P.D. have been made during the year of this list, besides 1,030 clock stars, and for instrumental corrections,

101 readings of collimation,
187 „ „ level,
159 determinations of azimuth.

Nadirs are taken immediately before and after the observations every clear night.

Owing to the reduced staff no regular work could be done with the equatorial. Advantage was taken of a visit to England by Mr. Cooke, to get him to select and have put in hand the best form of micrometer for the equatorial. This is now being made by Troughton & Simms.

The meteorological work of the Observatory, which forms the bulk of the annual volume, is fairly well up to date. Daily forecasts are issued and published at nearly every telegraph station, whilst at Adelaide and a few other principal offices maps are posted showing distribution of pressure, direction and force of wind, also reports on the general state of the weather, pressure, temperature and rainfall over Australia and New Zealand. The volume for 1893 has been published during the year, and those for 1894 and 1895 are now passing through the press. It is hoped shortly that a number of excellent sketches of Jupiter, by the late Mr. Sells, will be published, with notes on the physical appearance of the planet.

In 1896 January the Director visited Perth, by desire of the West Australian Government, to select a site for the new Observatory, which he fixed on Mount Eliza.

Hong Kong Observatory.

Hourly observations and continuous meteorological records, weather forecasts, storm-warnings, magnetic observations, and the public time-service have been continued as usual. All the typhoons that have appeared since the beginning of 1884 (about 300 in number) have now been investigated, and the tracks published in the *Observations and Researches made at the Hong Kong Observatory*, of which the twelfth volume has been published. A few observations of double stars and shooting stars have been made. Orbits of η *Coronæ*, ζ *Herculis*, and μ^2 *Boötis* have been determined by the method of least squares. A standard catalogue of 100 pairs of zenith stars has been constructed by aid of the latest and best catalogues, especially the Greenwich Ten-Year Catalogue. These pairs of stars have been observed in the transit-instrument according to Talcott's method in order to determine the latitude and its changes, and eventually the solar parallax through the constant of aberration.

The Observatory, Nungumbaukum, Madras.

During the past year the work of reducing the old observations has made considerable progress, and if no unforeseen delays occur the final catalogue for 1875·0 should be completed this year.

The investigation of the division errors of the meridian circle has been completed. A number of determinations of flexure have also been made, as the adopted value seemed based on too small a number of observations, especially as these varied largely amongst themselves.

At the close of the year a series of latitude observations were in progress in conjunction with Captain Burrard, R.E., of the G. T. Survey of India, with a view of tracing the cause of the difference between the values of the latitudes obtained by observations of circumpolar stars and observations made with the zenith telescope.

The building of the new observatory at Kodaikanal has not yet been begun, but all the plans and estimates have been completed and a certain amount of material has been collected. Sanction has also been obtained for the necessary apparatus, and contracts have been entered into for the construction of the chief instruments.

Melbourne Observatory.

Astronomical.—The following observations were made with the 8-inch meridian circle :—

Observations in R.A. clock stars	728
„ „ R.A. list stars	1,092
„ „ R.A. azimuth stars	233
Total	2,053
Observations in N.P.D. list stars	1,101
Observations for level	123
„ „ collimation	120
„ „ flexure	11
„ „ runs	45
„ „ nadir	116

The "list stars" are stars selected from the Astrographic catalogue plates (five from each plate), to be used as fundamental points in the reduction of the negatives.

The separate results and annual catalogue of stars observed in 1895 were prepared and completed.

Of the stars observed in 1896, the greater part are finally reduced, and the separate results and annual catalogue for 1896 are in course of preparation.

Astrographic.—Catalogue plates exposed	129
Plates on south pole for testing the transparency of the night	25
Plates for star trails	20
„ „ adjustment of centre	12
„ „ Oxford type regions	11
Chart plates set on odd degrees of declination	47

One picture of 47 *Toucani*, exposure three hours; taken at the request of M. Hansky, of the Poulkova Observatory.

The plates rejected on account of deficiency of sensitiveness, broken exposure owing to clouds, defects in the film, inaccuracy in setting, or other maladjustments, as follows :—

Catalogue plates rejected	5
Chart plates rejected	5

The exposures of catalogue plates were invariably 5^m, $2\frac{1}{2}^m$, and 20^s, and for chart plates one hour.

All catalogue plates subjected to the same preliminary examination as in previous years.

Time Service.—The time-ball was dropped at Williamstown

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at 1 o'clock statute time on 300 days, and time signals were sent throughout the colony at the same time daily, Sundays excepted. Seven failures occurred in the dropping of the time-ball, chiefly owing to accidental defects on the line.

Magnetical.—Photographic registration of the magnetic elements was carried on without interruption. Absolute measurements of magnetic declination, inclination, and horizontal component were made 12 times. The value of scales and of ordinates on photographic curves, &c., for the self-registering instruments, were made in March. Eye-observations of the variation in magnetic declination and horizontal component, at intervals of 5 sec., for periods of one hour at a time, were made at the request of Professor Bezold, of Berlin, in February and March last.

Meteorological.—The weather forecast was issued daily, Sundays excepted. Daily distribution of rainfall was prepared for the information of the public from records at 75 stations. Monthly statistics of rainfall and other meteorological elements, based on monthly returns from 540 stations, were prepared and published as usual.

Miscellaneous.—Rating of chronometers and testing of nautical and meteorological instruments for the public, at fixed charges, have been carried on as in previous years.

Special Cloud Observations.—This work was undertaken at the request of the International Meteorological Committee. Some 30 special volunteer observers were selected in various parts of the colony for observations of cloud form, direction of motion, and apparent velocity. They commenced their task on May 1, and will continue until the end of the year.

Also two stations (one of which is on the Melbourne Observatory grounds), situated at a distance of 6,820 feet from each other, were fitted for the purpose of determining absolute heights and velocity of clouds, by photographs taken simultaneously, with heavy metallic cameras permanently fixed on masonry piers, and with their optical axes pointing accurately to the zenith (Kew method). The work has just been commenced, and will continue for twelve months.

General Remarks.—The plates of the astrographic catalogue are now practically complete. A few scattered ones (some thirty in all) require to be taken again, and this will only require on the whole a few hours' work.

The resolutions taken by the Astrographic Conference at Paris in May last have given a good deal of uneasiness, owing to the large number of fundamental stars to be observed with the meridian circle for the reduction of the catalogue plates, and the increased time of exposure for one-half of the chart plates.

It had been contemplated that six fundamental stars in each plate (including the guide star) would be sufficient for the catalogue, and that one hour might be reckoned as the limit of

exposure for all the chart plates, but now that some 3,000 or 4,000 stars must be added to the list, for observation with the meridian circle, and three exposures of 30^m each are to be adopted for one-half of the chart plates, it is doubtful whether the Melbourne Observatory will be able to accomplish its share of the work within a reasonable time, even under the most sanguine expectations of liberality from the Government of Victoria.

So far no addition has been made to the staff of the Observatory. The position of chief assistant is still vacant, and the duties of the institution in connection with the demands of the public are continuously increasing, so that it has been impossible to undertake any equatorial work, or to deal with and publish observations accumulated in past years.

In the Director's last report to the Board of Visitors, he asked for three assistants to be employed solely in the measurement and reduction of the astrographic catalogue plates, and another assistant for general duties, but this request has not yet been dealt with.

Perth Observatory, Western Australia.

This Observatory is not yet in working order. Mr. W. Ernest Cooke, M.A., was appointed Government Astronomer in February, and after discussing plans with the colonial architect, and making a few alterations in the meteorological arrangements, he was instructed to proceed to England to inspect the astronomical instruments then being constructed. The principal ones are an astrographic equatorial by Sir Howard Grubb, and a transit circle by Messrs. Troughton & Simms. The former is similar to those generally adopted for the Astrographic Chart—13 inches photographic, and 10 inches visual. Sir Howard Grubb is also constructing a 20-foot dome and a chronograph similar to that made by him for Dr. Gill, and regulated by his "Mouse" control. The transit circle is of 6 inches aperture, and promises to be an exceptionally fine instrument. In order to eliminate as far as possible irregular refractions due to differences of temperature in the immediate neighbourhood of the telescope, a transit-room, of Dr. Gill's proposed form, is being constructed (*vide* Introduction to Cape Catalogue, 1885). The walls and roof will be made of papier-maché fixed to a wooden skeleton, and protected from direct sunlight by iron louvres painted white, and the floor, of iron, will be raised three feet above the ground, leaving a space underneath for free circulation of air.

A number of meteorological instruments were also obtained, including six platinum resistance thermometers from the Cambridge Scientific Instrument Company, for registering earth temperatures, and for use in the openings of the transit shutters, if experiment proves their reliability for this purpose.

On his return, Mr. Cooke inspected all the meteorological

stations in the colony, establishing a few fresh ones, and supplying all with thoroughly reliable instruments. It is proposed to keep in touch with the observers by means of an annual inspection, and it is hoped that valuable meteorological information will shortly be available for this extensive territory.

Sydney Observatory.

Staff.—There has been no change in the astronomical staff, but the first assistant in the meteorological staff died on March 2, and the position has been filled by the promotion of Mr. H. A. Hunt to the position of first assistant.

Buildings.—The shutters of the large dome have been taken out and worn out friction rollers have been replaced by new ones. The shaft of the time-ball, which was made of wood, was found to be in a dangerous condition from decay, and has been removed and replaced by one made of iron. While these repairs were going on the time-signal was given by a temporary ball, erected on the tower three feet north of the permanent one. The wood-planking on the flat roof between the north and south domes, having become unsafe by decay, has been replaced.

Weather.—We have had another year of drought, and its usual accompaniments, dust, haze, and bad definition, have made it impossible to take measures of double stars, or photographs on many otherwise fine nights. This drawback affects the photographic work more seriously than it does the double star measures, for a slight haze suffices to produce a serious fog on long exposure chart plates.

Meridian circle.—With the meridian circle only 1,613 transits were observed ; of these 470 were sun-transits. 1,034 north polar distances were observed, 66 determinations of the flexure of the instrument have been made at different temperatures, and the series is now complete. Azimuth was determined on 92 nights, collimation determined 290 times, level 377, and nadir 375 times. The precessions in R.A. and N.P.D. for all stars observed in 1893 -94 and 1895 have been computed and lists prepared for press. The computations of stars observed in 1896 are well forward.

Equatorial.—Only 55 evenings were available for double-star measures, and 45 pairs have been measured, by 574 settings for position angles, and 646 for distances. Two evenings were devoted to the search for comets, and were unsuccessful ; 24 evenings had to be given to visitors.

Star Photography.—Reference has already been made to the weather drawbacks affecting this work, and the fact that nearly every night was devoted to long exposure or chart plates will account for the comparatively small number of chart plates. The total number of photographs taken during the year was 375 ; of these 16 were for catalogue, 4 on special objects, and 355 for

chart. All but 20 were therefore long exposures of 30 to 45 minutes ; the plates used being such as give a good image of an 11 magnitude star in one minute.

Meteorology.—The meteorological work has been carried on as usual, the steady increase in the number of stations being maintained. The volume for 1895 has been published, and that for 1896 is nearly ready for press.

General.—During the year 1,472 copies of publications have been sent out, and 962 publications received from other observatories. The number of visitors steadily increases, and, I fear, must continue to do so while the Observatory remains in the heart of the city. A very fine site for the Observatory has been selected out of the city, and ten miles farther from the sea. It has an altitude of 615 feet, and an effort will shortly be made to get the astronomical instruments removed to the new site.

Lovedale, South Africa. (Mr. A. W. Roberts's.)

The work here has been the regular observation of variable stars south of −30° Decl. Two new variables were discovered during the year, one in *Carina* and the other in *Centaurus*. The latter star belongs to Class II. type of short period variation.

Observations were made on 150 nights, the details of work being as follows:—

Algol variables (4 stars)	797	observations
Short period variables, Class I. (18 stars) ...	1,528	,,
,, ,, ,, Class II. (1 star) ...	524	,,
Long ,, ,, (29 stars)	1,002	,,
Suspected variables (30 stars)	227	,,
Total	4,078	,,

Each observation is the mean of two others, one direct and the other reverse. In this way the chief possibilities of error in the determination of magnitudes by eye estimates—*viz.* mental bias and position error—were considerably reduced.

It is intended during 1897 to discontinue observations, to permit of a discussion of all the observations taken at Lovedale during the past six years, and also to make arrangements for a survey by eye estimates of the magnitudes of all stars between $6^{m}\cdot0$ and $9^{m}\cdot0$ south of −30° Decl.

Mr. Tebbutt's Observatory, the Peninsula, Windsor, N. S. Wales.

With the exception of the opening and closing months, the year 1896 has been characterised by clear skies, and as a consequence, an unusually large amount of both meridian and extra-

meridian work was done. The local sidereal time was determined on 221 nights, and for this purpose 1,485 transits of stars were observed. Of these transits, 1,230 were of stars with a declination not exceeding 40°, and 255 of stars in high declination for azimuth. The separate determinations for the level, collimation, and azimuth errors of the transit instrument were respectively 536, 54, and 237. Although the changes of azimuth were not great, it is interesting to note that the gradual falling of the eastern pivot during the year 1895 continued till the middle of February, when the apparently compensatory rise of the pivot began, and this continued right through the year.

The results in the extra-meridian department are about the richest obtained in any one year since the foundation of the Observatory. 161 phases of lunar occultations of stars were observed, mainly with the 8-inch equatorial. These comprise 132 disappearances at the dark, and 11 at the bright limb, and 12 reappearances at the dark, and 6 at the bright limb. Fifteen *Nautical Almanac* stars were observed in both phases. For the 161 phases, 109 stars have been identified, and the places of the remaining fifty-two stars were approximately determined at the time of observation. It is very desirable that some meridian observer should at once take up the observation of the fifty-two unidentified stars, so that in the utilization of the occultations at a future period all doubt as to proper motion might be avoided. During the past thirty-three years 853 occultations have been observed, and although the year 1895 was the record year in this department, presenting as it did sixty-five observed phases, it has been surpassed by that just elapsed. Mr. Joseph Brooks, F.R.A.S., during the year 1896, again kindly furnished the Observatory with predictions of occultations of *Nautical Almanac* stars.

The 8-inch equatorial has also done good service in the observation of minor planets. The following is a statement of the work in this department :—

Planet.	Nights of Observation.	No. of Comparisons.
Hebe (6)	... 11	162
Flora (8)	... 9	113
Parthenope (11)	... 18	196
Calliope (22)	... 8	84
Danaë (61)	... 7	75
Sappho (80)	... 3	34
Undina (92)	... 4	55
Siwa (140)	... 10	91
Totals	... 70	810

Hebe and *Parthenope* were observed at the request of Dr. Luther, of Düsseldorf, and *Calliope* and *Siwa* at that of Dr. Bauschinger, of Berlin.

There has been no comet sufficiently bright to be observed with the 8-inch telescope. Notice of the discovery of the comet *Perrine* was received on December 11, but cloudy weather prevailed till the 15th, when a search was made in the bright moonlight, but without success. A search was again made after the withdrawal of the Moon on the 22nd, but this was also unsuccessful.

The phenomena of *Jupiter's* satellites were closely watched and recorded during the first five months of the year. During the same period two remarkable dark spots were observed on the disc of the primary. Nine transits of one spot and seventeen of the other were observed across the central meridian of the planet. Ephemerides of these spots were likewise circulated from the Observatory in the hope that they might be independently observed elsewhere.

In consequence of the observer's close application to other departments of observation, much attention could not be paid to double-star work. Seven evenings were devoted to this work, during which 199 settings were made for position angles, and 153 double measures for distance. The following double stars were measured :—*p Eridani*, *Lacaille* 2145, *V Puppis*, *γ Piscis Volantis*, *γ Centauri*, *β Muscæ*, *a Centauri*, and *A Scorpii*.

In the variable star department a few observations of *T Centauri* and a well connected series of *R Carinæ* were secured. The latter star was compared with neighbouring stars on thirty-three evenings. Its maximum occurred about March 8 with a magnitude of 5·3 of the scale of the *Uranometria Argentina*. At the close of the year it was again approaching its maximum, the magnitude being estimated at 4·9.

The meteorological observations have been regularly made, and the summer of 1895–96 proved to be the hottest experienced since observations were commenced in 1863. On January 6, 12, 13, 18, the highest shade temperatures were respectively 116·5, 116·6, 118·4, and 115·9. Many deaths occurred in the colony from heat apoplexy. The excessively hot summer may be regarded as nature's compensation for the extraordinary cold winter of 1895.

In conclusion, it may be stated that the proprietor has made all the astronomical observations and executed fully three-fourths of the reductions. The greater portion of the meteorological observations and their reductions has also devolved upon him.

Notes on some Points connected with the Progress of Astronomy during the Past Year.

Discovery of Minor Planets in 1896.

Twenty-three new planets were discovered during the past year as follows :—

Provisional Designation.	Permanent Number.	Name.	Date of Discovery, 1896.	Discoverer.	Place of Discovery.
CH	410	...	Jan. 7	Charlois	Nice
CJ	411	...	7	,,	,,
CK	412	Elisabetha	7	Wolf	Heidelberg
CL	413	Edburga	7	,,	,,
CN	414	...	16	Charlois	Nice
CO	415	...	Feb. 7	Wolf	Heidelberg
CP	...	...	Apr. 2	,,	,,
CQ	...	...	21	,,	,,
CR	...	...	21	,,	,,
CS	416	...	May 4	Charlois	Nice
CT	417	...	6	Wolf	Heidelberg
CU	...	...	Sept. 3	,,	,,
CV	418	...	7	,,	,,
CW	419	...	7	,,	,,
CX	...	...	7	,,	,,
CY	420	Bertholda	7	,,	,,
CZ	421	Zähringia	7	,,	,,
DA	422	*Berolina*	Oct. 8	Witt	Berlin
DB	...	...	Dec. 7	Charlois	Nice
DC	...	...	28	,,	,,
DD	...	...	31	,,	,,
DE	...	...	31	,,	,,
DF	...	...	31	,,	,,

Planet CE, discovered 1895 December 9, has been numbered 409.

The planet provisionally designated CM proved to be identical with (332) *Siri*.

Planet 417 was independently discovered by Charlois on May 8.

The following planets have been named :—(324) *Bamberga*, (330) *Adalberta*, (337) *Devosa*, (338) *Boudrosa*, (340) *Eduarda*, (341) *California*, (342) *Endymion*, (343) *Ostara*, (345) *Tercidina*, (346) *Hermentaria*, (347) *Pariana*, (351) *Yrsa*, (352) *Gisela*, (385) *Ilmatar*, (391) *Ingeborg*. It will be recollected that the name *Ilmatar* had previously been given to another planet which was afterwards found to be identical with (298) *Baptistina*.

From some large discrepancies from theory in the motion of (151) *Abundantia*, Herr Groeben suggested in *Ast. Nach.* 3,372, that there might be two neighbouring planets travelling in almost identical orbits, of which sometimes one had been observed and sometimes the other. Herr Villiger, however, observed *Abundantia* in October last, and searched the neighbourhood for a companion planet without success.

M. Gustave Ravené has made an estimate of the mass of the entire group of minor planets (*Ast. Nach.* 3,356). He assumes that the excess of 5″ per century in the motion of the perihelion of *Mars* above its theoretical value is due to their action, and hence deduces that their total mass is $\frac{2}{3}$ of that of the Moon. Herr Harzer, however, considers that there is some error in his investigation, and that a mass eighteen times as great would be required to produce the observed effect.

Three investigations of the perturbations of minor planets by *Jupiter* have been published during the year. Herr Ludendorff, in *Ast. Nach.* 3,349, examines the motion of the outer members of the group, and gives tables for facilitating numerical computation.

Dr. Olsson and Dr. Martin Brendel examine (*Ast. Nach.* 3,357 and 3,346 respectively) the case of planets whose period is approximately commensurable with that of *Jupiter*.

The following planets have been observed at a second opposition since the date of the last Report :—309, 332, 339, 342, 356, 358, 364, 367, 385, 386, 391, 402, 405.

A. C. D. C.

The Comets of 1896.

Omitting mention of Faye's Comet, which passed through perihelion last March, but which was re-observed in 1895 September (see *M. N.* vol. lvi. p. 253), six comets have been certainly discovered during the year. Two or more suspicious objects, which have been seen only once, are not included in this summary.

The history of the first cometary discovery of the year is not a little curious. A telegram sent from Kiel to the Lick Observatory concerning the re-observation of Perrine's Comet of 1885 November after perihelion passage was incorrectly transmitted, and the place did not agree with the observations made at Lick

Observatory, where Perrine's Comet had been regularly observed since January 29. This confusion induced Mr. Perrine to examine the part of the sky indicated in the telegram, and there he found a comet, which he was enabled to announce as new, on February 14. On the following morning Dr. Lamp, of Kiel, independently convinced himself of the existence of a new comet. The two comets, both situated in *Aquila*, made the closest approach on February 16, when they were separated by rather more than two degrees. The new comet was brighter than the one of the previous year, and was moving rapidly north, but growing fainter, the perihelion passage having been passed on the last day of January. The elements do not greatly differ from a parabola. M. Schulhof's attempt to determine the eccentricity led to a hyperbola, but later deductions have not supported this view. The comet was photographed by MM. Josef and Jan Fric, in Prague. The most successful negative on February 22 shows a tail in position-angle 320° of two and a half degrees in length, with a dark line running through the centre.

Dr. Lewis Swift announced on April 13 the discovery of a comet which he had probably seen some days earlier, but of which he had been unable to recognise the true character. This comet was tolerably bright at the time of its discovery, but placed too near the horizon for favourable observation. As it moved northwards it diminished in brilliancy, and by the middle of June the comet had passed out of reach of all but the largest telescopes. Its short course is satisfactorily represented by a parabola.

The next discovery in point of time, though not in order of perihelion passage, was effected by M. Javelle, of the Nice Observatory, who, on June 20, successfully picked up Brooks' Comet of 1889 (see *M. N.* 1890, p. 218). The definitive elements of this comet, based on the observations of 1889, were deduced by Dr. Bauschinger, and the ephemeris that led to the discovery is also due to the same computer ; but the calculation of the effect of perturbation on the circumstances of this return was made by Dr. Lane Poor, who was particularly interested in this comet on account of its possible identity with that of Lexell. That the orbit is fairly accurate is shown by the small difference that separates the observations from Dr. Bauschinger's ephemeris (24^s in R.A., and $2''.5$ in declination), indicating a passage through perihelion about one-fifth of a day later than that employed in the ephemeris. The smallness of this correction, pointing as it does to the accuracy of the original elements determined from the 1889 return, does not favour the probability of an identity between this comet and that of Lexell. To establish this identity very considerable perturbations by *Saturn* were needed, and this disturbance is not indicated. Moreover, the improved value of the mean motion, based, it must be admitted, on a very few observations, indicates an extremely close appulse to *Jupiter* in 1791, and such an appulse clearly indicates that the two comets are not one and the same. Unfortunately, the question is still further

complicated by the appearance that the 1889 comet presented. The principal nucleus was then seen to have several nebulous companions, and it is not impossible, owing to variations in brilliancy then noticed, that the observations at this return do not belong to the same nucleus as was then under observation. Companion comets have been looked for in the neighbourhood of the Javelle comet, but without success. This, however, may be due to the faintness of the nucleus at the present apparition. At the time of its greatest brilliancy, in September, it was beyond the reach of moderate apertures.

The fourth cometary discovery of the year was made by Mr. W. E. Sperra, of Randolph, Ohio, on August 31, but owing to difficulties of communication with Harvard, and some little delay at the Allegheny Observatory, the fact was not published till after the discovery had been repeated by Mr. Brooks, of Geneva, with whose name the comet was first connected. The comet was tolerably large and diffuse, and from its circumpolar position at the time it was first seen should have been very generally observed. But it remained a very faint and difficult object in ordinary telescopes, and by the end of September had practically ceased to be observable. The orbit, which is very nearly perpendicular to the ecliptic, is probably parabolic.

Pending the announcement of the Sperra-Brooks Comet, but subsequent to the actual discovery, M. Giacobini, of the Nice Observatory, detected a faint comet in the constellation *Ophiuchus*. This object proved itself still more difficult than the last, being less than two minutes in diameter and of considerable southern declination. But the orbit, though at present uncertain, is likely to prove very interesting from its elliptic character. The first ellipses computed gave a very short period, and, indeed, the early observations could be satisfied with a period of only 510 days. Later observations, carried on at Lick Observatory till the end of October, disclose, however, a period of nine years.

On November 2, Mr. C. D. Perrine found another comet, making the fifth in the year. It was tolerably bright, but moving southwards towards perihelion, and at the beginning of 1897 is practically lost by proximity to the Sun. When again at a sufficient elongation for observation, it will be visible only in the southern hemisphere. The perihelion passage does not occur till next February, but the time of its maximum brilliancy is next April, when it will be six times as bright as when discovered, and probably be visible to the naked eye. It may be again observed in this hemisphere next summer.

The last comet of the year was also discovered by Mr. Perrine, on December 8. It was a tolerably bright telescopic comet, stated to be equivalent in brilliancy to a star of the eighth magnitude. This comet was also moving southward and diminishing in lustre, having passed its perihelion in November. The elements of the orbit are still somewhat uncertain, but the latest

discussion shows that the orbit is elliptical, and that the elements have some similarity with those of Biela's Comet.

In addition to this somewhat lengthy list, it should perhaps be mentioned that in 1895 December, M. du Celliée Muller, of Nymegen, announced to the editor of the *Astronomische Nachrichten* that he, in company with Herr G. J. Van Dyk, had discovered a comet quite close to *Venus*. This object was described as bright, with a tail inclined to the horizon at an angle of 35°. This comet has not been seen elsewhere, though sought for in various observatories; neither will the direction of the tail accord with the position of the Sun. M. Muller, however, insists on the impossibility of his being mistaken. In connection with this rather doubtful observation may be mentioned another, reported by Dr. Lewis Swift, of one or of two comets which he, in company with fifteen other persons, saw near the Sun on September 20. This observation has not been verified. On September 21, Dr. Swift reports that he, with a small telescope, saw one comet only; but no place is given. W. E. P.

Progress of Meteoric Astronomy in 1896.

January and April Meteors.—Very little was observed of these displays owing to moonlight and cloudy weather. Prof. Herschel, however, watched for meteors on several nights between April 9 and 22, and registered 35, of which about 6 were *Lyrids* from a radiant indistinctly marked at 275° + 38°, and 5 from a bordering shower of *Draconids* at 270° + 48°. Other radiants were indicated at 257° + 62°, 209°—7°, and 213° + 52°.

August Meteors.—These were fairly well seen at several stations on August 10, but the display was not an abundant one. At Bristol, during the interval of $4^h\ 25^m$ from $9^h\ 50^m$ to $14^h\ 15^m$, 98 shooting stars were seen, of which 69 were *Perseids*, from a radiant at 45° + 57°. Mr. Blakeley, of Dewsbury, counted 35 *Perseids* between 11^h and $12^h\ 30^m$, and they gave a sharply defined radiant at 43° + 58°. Mr. S. H. R. Salmon, of Croydon, saw 20 meteors (15 *Perseids*) between $9^h\ 10^m$ and 10^h, and 18 meteors (16 *Perseids*) between $10^h\ 10^m$ and 11^h, the sky being perfectly clear. Mr. Corder saw 30 *Perseids* with radiant at 47° + 58°. On August 12 he counted the same number of *Perseids*, and fixed the radiant at 48° + 60°. Mr. Booth, at Leeds, watching the sky on August 11, 10^h to $10^h\ 45^m$, recorded 18 meteors, and found the *Perseid* radiant very diffuse, with a centre at about $47\frac{1}{2}°$ + $58\frac{1}{2}°$. Mr. Milligan, of Belfast, noted 10 *Perseids* on August 5, from 37° + 57°, 22 on August 9, from 47° + 58°, and 8 on August 15, from 50° + 58°. From a comparison of the radiants determined on different dates, the shifting of the centre is shown in a very conclusive manner. Several *Perseids* were doubly observed and their real paths computed. On August 10, $10^h\ 6^m$, a bright meteor of

this shower was registered at Bridgwater and Bristol, and it traversed a course of 47 miles, descending from 75 to 49 miles over Reading to Southampton, with a velocity of about 32 miles per second.

November Meteors.—It was confidently expected that this shower would exhibit a very marked increase of strength this year, but, though observations were pretty numerous, it seems to have disappointed expectation. The *Leonids*, it is true, formed a well marked shower, but they may be said to do this nearly every year; on the whole, however, the display was certainly more actively defined than usual, though the horary number was only 8 or 10 at the richest time, viz. the morning of November 15. One observer, writing from Scotland, says there was quite a shower of meteors there—about 60 being counted between 5^h 15^m and 5^h 45^m on the morning of November 15, but this report lacks confirmation. From America there are some doubtful descriptions of a fine shower, as many as 12 at a time being seen, and some were so large as to be visible at noonday. The following is a summary of some of the best observations to hand from English and continental observers :—

Date.	Hours of Observation.		Duration.	Meteors Seen.	Leonids.	Observer.
	h m	h m	h			
Nov. 12	...	...	$2\frac{1}{2}$	20	5	Corder
13	14 0	17 20	$3\frac{1}{4}$	33	15	Corder
13	11 15	16 30	$5\frac{1}{4}$	131	70	Riggenbach and 5 others
13	14 10	18 10	4	56	29	Anderson
13	12 0	16 15	$4\frac{1}{4}$	40	12	Blakeley
13	13 55	16 55	3	22	15?	Martin
13	14 8	18 10	4	56	29	Anderson
14	12 0	18 0	6	46	34	Herschel
14	16 0	18 0	2	19	11	Denning
14	12 30	14 0	$1\frac{1}{2}$	15	9	Milligan
14	14 0	18 15	4	66	43	Corder
14	17 38	18 42	1	...	7	Besley
14	8 3	9 33	$1\frac{1}{2}$	27	12	Meares
14	13 40	17 49	$3\frac{1}{4}$	25	23?	Martin
14	12 0	17 20	5	75	46	Thompson Tanner

Radiant Point.

$148^\circ + 23^\circ$	Herschel	$149^\circ + 22^\circ$	Besley
$146 + 25$	Corder (13th)	$150 + 22\frac{1}{2}$	Denning
$150 + 23$	,, (14th)	$149 + 23$	Milligan
$150 + 24$	Blakeley	$152 + 21$	Meares

Several *Leonids* and other meteors were doubly observed—two of the latter were from a radiant at 133° + 32°, and corroborate one of the many minor showers of the epoch. Another, seen on November 12, was from a radiant in the head of *Cetus* (45° + 4°), and was quite a brilliant object, giving a flash which lit up the sky ; but it appears to have been seen by not more than 3 observers. Of the lesser streams which always manifest themselves at the middle of November, Prof. Herschel re-observed three from the points 150° — 12°, 135° + 17°, and 155° + 35°. Summing up the results, it may be briefly stated that the *Leonid* shower of 1896, if not very rich, formed an interesting display, and gave promise of a returning strength which will be sure to be further developed in 1897. As to photographic methods, it does not appear that successful efforts have been made to determine the radiant.

December Meteors.—These formed an active display on December 11. Mr. J. Evershed, at London, watched the sky during the half-hour from $12^h\ 50^m$ to $13^h\ 20^m$ on that date, and counted 32 shooting stars, of which about 27 were *Geminids* from a radiant not well defined at 117° + 25°. "The meteors were rather swift, but without trails ; the brighter ones were a fine blue colour, and many fell apparently near to the horizon." Mr. D. Booth, at Leeds, saw about 20 *Geminids* on the same evening, and estimated their radiant as at 110° + 31°. At $12^h\ 24^m$ he recorded a brilliant meteor of the stream, about 2 × ♀, with a path from 55° + 35° to 25° + 25°. Prof. Herschel mapped nine tracks between $11^h\ 55^m$ and $12^h\ 25^m$ (rate of 18 per hour), when the sky clouded over. On December 12, 10 or 12 *Geminids* were mapped from 10^h to 12^h (rate of 5 or 6 per hour), showing the maximum certainly took place on December 11. Mr. Blakeley watched on December 11 for about 1 hour, and saw over 20 *Geminids* with a rather diffused radiant at about 110°+34°. Mr. Corder gives the following figures as the results of his observations at Bridgwater :—

Date.	Period of Watch. h m h m	Total No. of Meteors.	Geminids.	Radiant. ° °
Dec. 9	8 50 to 12 0 at intervals	39	22	111 + 34 115 + 32 103 + 34
11	10 0 to 15 0	111	89	110 + 34 112 + 30
12	14 0 to 16 15	30	21	111 + 33

Fall of a Meteorite at Madrid.—In the bright sunshine and blue sky of February 10, at $9^h\ 29^m\ 30^s$ A.M., a fireball of great lustre was seen at Madrid. It left a white streak about 6° long and 1° wide, a few degrees S.E. of the zenith ; it soon became

semicircular in form, and looked like a film of cirro-cumulous cloud. Ten seconds after the meteor flashed out there was a strong detonation, which lasted two minutes. The glass windows of some of the houses were broken by the vibrations. From the position of the meteoric cloud the body must have proceeded from S.E. towards N.W., and burst near the zenith of Madrid. It slowly drifted eastwards under the action of currents in the upper air, but was still visible at 3 P.M., $5\frac{1}{2}$ hours after its first projection, when its position was 20° above the eastern horizon.

Some pieces of the meteor fell in the suburbs of Madrid. One fragment obtained by Signor Arcimis (to whose account in *Nature* for February 27 we are much indebted) was of a black metallic aspect; inside it was of a white stony appearance, with some brilliant points like nickel. It weighed 6·3 grams. The phenomenon was visible over a considerable region of the peninsula. An analysis of one of the stones has since proved it to consist of the silicate of magnesium and iron, containing also estimable quantities of aluminium, nickel and calcium.

Fireballs.—On March 16 $10^h\ 13^m$ a very fine meteor, leaving a train, was seen at Bridgwater and Stratford-on-Avon. Its radiant was in *Libra*, and the end point of its flight is indicated at a height of 29 miles above Llanfain, N. Wales.

On April 8 $8^h\ 20^m$ a meteor brighter than *Venus* was widely seen in England. Its course was from over the Straits of Dover to the south part of Leicestershire, and it descended from 65 to 38 miles. Length of observed path, 161 miles; velocity, 20 miles per second. Its radiant was in *Libra*, like that of the meteor of March 16.

On April 12 $8^h\ 6^m$ a large fireball, emitting sparks, was observed. One spectator estimated its brightness as twice that of the full Moon. A large number of observations were collected of this object, and it appears to have radiated from a point near *a* or *ζ Persei*. When first seen, it was 118 miles high over Formby, and at its disappearance was 34 miles high over Doddington, Cambridgeshire. Real length of path, 177 miles, and velocity, 19 miles per second.

On September 10 large meteors were observed at $9^h\ 3^m$ and $10^h\ 26^m$. The first was brighter than *Venus*, and left a long streak for about 30 secs. It had a radiant in *Auriga* at 72°+42°, and fell from 82 to 65 miles over the Irish Sea. The second was many times brighter than *Venus*, and had a radiant near *β Cephei* at 330°+71°. It fell from an elevation of 71 to 30 miles above Herefordshire.

On November 12 $11^h\ 8^m$ a fine meteor was seen at Reading and Cardiff. It appears to have had a radiant at 45°+4° in *Cetus*, and to have fallen from 52 to 29 miles.

Association of Comets and Meteors.—Considering the large number of computed orbits of comets and of meteoric streams, surprise has occasionally been expressed that very few satisfac-

tory instances of connection have been detected between them. When, however, it is remembered that comparatively few comets pass near the Earth, the rarity of such accordances will be easily understood. Professor A. S. Herschel recently consulted Galle's Catalogue of Cometary Orbits to 1893, to ascertain if any resemblances could be discovered between recent comets and meteoric systems. The result of his examination is curious and surprising, for during the last 20 years only two observed comets (among upwards of 80 newly-discovered comets) have approached the Earth's orbit pretty closely. These were 1881 V. (Denning) and 1886 VII. (Finlay). The former approaches us within ·032 of the Earth's radius vector, while the latter passes it within ·05. These values correspond to distances of about 3,000,000 and 4,600,000 miles respectively. Comet 1881 V. would have a radiant point on December 14 at 277°-34°, near ϵ *Sagittarii*, but as the Sun is in long. 262° on that date, the radiant sets with the Sun, and thus the meteor shower, if any, is practically extinguished by daylight. Comet 1886 VII. has a radiant on October 5–6 in the head of *Sagittarius*, and its position enables it to be well visible in the early evening hours ; but no meteoric shower has ever been observed from *Sagittarius* in October. It might be well to look for such a display, however, when the comet is near perihelion, as in 1899 October. But the nearest approach of the orbits of the Earth and comet may not be sufficiently close to originate a meteoric shower. Comet 1866 I. (Tempel), which produced the brilliant *Leonid* display of that year, passed within ·017 of the Earth's orbit, or at a distance of about 1,600,000 miles, which is about one-third of the interval separating us from the orbit of Comet 1886 VII. (Finlay) at its nearest point.

Among the recently published contributions to meteoric literature may be mentioned *Meteors and Sunsets*, forming No. 5 of the Lick Observatory publications. This work contains a discussion of the observations of the fireball of 1894 July 27 by Professor E. S. Holden, also observations of the *Perseids* by Messrs. Schaeberle, Colton and Perrine. The British Astronomical Association's Annual Report on Meteors was issued in 1896 June, and contains a mass of interesting details of recent observations by Members of the Meteoric Section. In the *Astr. Nach.* 3,360 (1896 June 15) Dr. Doberck gives a catalogue of 31 radiants observed at Hong Kong in the years 1891–5.

W. F. D.

Solar Activity in 1896.

A further decline in the general activity of the chromosphere is shown by the 1896 observations. Taking the year as a whole, the mean activity with regard to prominences has diminished by about 30 per cent. as compared with the previous year. A well-marked minimum occurred in April and the first half of May,

when at times the chromosphere appeared almost entirely undisturbed. Excepting this period, however, prominences have been tolerably abundant throughout the year in equatorial and mid-latitudes ; the parallels $\pm$ 55°, as in 1895, marking a pretty definite limit in the distribution. The polar regions have been practically inactive.

The general distribution again clearly negatives any direct connexion between the ordinary type of prominence and faculæ. Professor Tacchini's results for the first six months of the year show that prominences have been about equally numerous in the two hemispheres, from the equator up to latitude $\pm$ 50° ; whilst the faculæ have been most frequent south of the equator with maxima in the zones $\pm$ 10° to 20°.

Of the total number of prominences of all kinds observed at Kenley and Sevenoaks, 2·3 per cent. reversed the sodium and magnesium lines ; whilst the helium line at w. l. 6678 and the corona line (5316) were each recorded once only. These metallic prominences were found in the regions + 6° to + 33° and − 9° to − 40°, and were most frequent in the southern hemisphere, closely corresponding therefore with the faculæ and spots.

Reversals and distortions of the hydrogen lines on the Sun's disk have accompanied certain spot groups, notably on June 11, 12, and 13 in latitude − 16°/21°, on July 14, 17, and 20 in latitude − 19°/25°, and in the great group of September, on September 16.

No records of eruptions on a large scale have been received.

So far as the numbers and areas of sun-spots are concerned, the decline in the solar activity recognisable in 1894 and 1895 became very marked in 1896. For the first time since 1891 March 28 there were days when the disk was entirely free from spots, four such instances being recorded during the months of April and May. And the general decline in the mean daily spotted area was most considerable, both Professor Tacchini, at Rome, and M. Guillaume, at Lyons, giving the value for 1896 as but three-fifths of that for the preceding year, a value in close accord with that derived from the photographic record at Greenwich, so far as that is yet complete. The decline in the area of the faculæ has, however, been much less pronounced, the figures given by M. Guillaume showing a falling off in the year just past of about 28 per cent., whilst Professor Tacchini even records a slight recovery.

As to distribution in latitude, both spots and faculæ show a well-marked preference for the zones 10° to 20° on both sides of the Equator ; the slight predominance shown by the northern hemisphere in 1895 has now disappeared, and the southern is once again distinctly the most prolific both for spots and faculæ.

Little change seems to have taken place in the mean latitude of the spots ; the general tendency is for the mean latitude to slightly decrease, and spots above 20° have been rare. On the other hand, M. Guillaume has recorded two instances of very small short-lived spots in latitudes of 44° and 47°.

The most remarkable spot-group of the year was that of September 10–22. It attained a maximum area of 2,000 millionths of the Sun's visible hemisphere, but its chief characteristic was its unusual length, extending as it did over 24° of solar longitude, the various spots which made up the stream following each other, during the earlier days of its appearance, so closely as almost to form one continuous rift.

Total Solar Eclipses.

1893 *April* 16.—Since the date of the last report, two additional papers have been published on this eclipse.

M. Deslandres has collected the report and discussion of his observations into a volume published by the Bureau des Longitudes (*Observations de l'éclipse totale du Soleil du 16 avril 1893*). This volume adds little to what has been already discussed by M. Deslandres in the *Comptes Rendus*, but there is one point that we may mention. This is with reference to the supposed detection of the rotation of the corona. It will be remembered that by observation of the relative movements in the line of sight of the two parts of the corona, or opposite limbs of the Sun, as determined spectroscopically, it was claimed that evidence had been obtained showing that the corona partakes of the Sun's rotational movement. This deduction was made from measurements of photographs of the bright H and K lines, and not, as before stated, from visual observations of the 1474 K line. In view of the fact that both the prismatic camera and the slit-spectroscope show that H and K do not occur in the spectrum of the corona, it seems impossible to reject the conclusion that the observation in question must be explained in some other way. It is unfortunate that the visual observations of the 1474 K line, which failed for want of light, were not successful.

Professor Norman Lockyer has published a full report of the results obtained with the prismatic cameras (*Phil. Trans.* vol. 187 (1896) A). The excellent series of photographs taken by Messrs. Fowler and Shackleton have yielded a number of interesting results, of which we may briefly mention a few. There is, firstly, the great difference in the forms of the prominences as seen in the different radiations, those in H and K being most intense and reaching to the highest level. The forms of the prominences photographed in the H and K light do not appear to differ sensibly from those photographed directly with the coronagraph. Neither H nor K, nor any of the hydrogen lines, nor D_3 were seen in the spectrum of the corona. It will be remembered that in the early days of eclipse work many observers reported that they had seen bright hydrogen lines in this spectrum. Professor Schuster in his discussion of the results of the 1886 eclipse came to the conclusion that calcium and hydrogen do not form part of

the normal corona spectrum, and we may now accept this as a well-established fact. With regard to D_3, which, being in a non-actinic region of the spectrum, has been photographed only with the prismatic camera, there is not at present quite the same weight of evidence, but there is no reason to doubt that this radiation also is confined to the chromosphere and prominences.

As regards the true spectrum of the corona, the positions of seven lines in addition to 1474 K were measured. These coincide to a certain extent with the results obtained from slit-spectroscopes, but in view of the apparent variability of the corona spectrum and the extreme faintness of the lines it would seem that we have not yet collected sufficient data for a useful discussion. Professor Lockyer is of opinion that the eclipse work strengthens his view that chemical elements are dissociated at solar temperatures, but the question as to the chemical origin of the lines is reserved for a future paper.

1896 *August* 9.—The preparations made to view this eclipse were for the most part nullified by bad weather. A party consisting of the Astronomer Royal, Professor Turner, and Captain Hills went to the island of Yezo, where also were stationed two Japanese parties under Professors Terao and Hirayama, a French party under M. Deslandres, and two American parties under Professors Schaeberle and Todd respectively. Dr. Common and Professor Norman Lockyer, Dr. Copeland, a party about eighty strong of the members of the British Astronomical Association and their friends, and many other observers too numerous to mention in detail, were located on the shores of the Varanger Fjord, Finmark, Norway. At none of these stations was the eclipse seen. It was seen under perfect weather conditions at Bodö, on the west coast of Norway, where, unfortunately however, there were no fully equipped observers. The various Russian parties, at Orlovski, on the Amur, at Tiumen, in Western Siberia, at Siikavuopio, in Swedish Lapland, and in Novaia Zemlya, were fairly fortunate, and obtained several photographs. A small party of English observers, consisting of Mr. Stone and Mr. Shackleton, were kindly taken by Sir G. Baden-Powell in his yacht to Nova Zembla, and, being favoured with exceptionally fine weather, an excellent series of photographs was procured. The discussion of these results has not yet been published, and we must defer a full notice of them till next year.

One result obtained is, however, so important that it deserves mention, and that is the photographing by Mr. Shackleton of the "flash" spectrum at the beginning of totality. Attempts have before been made to secure a record of this phenomenon with the prismatic camera, but have not hitherto been successful. On this occasion, however, the long-desired photograph was secured, and we are now in possession of a record of the much-disputed "reversing layer." Prof. Young has expressed the opinion, based on an examination of the photograph, that the spectrum photographed by Mr. Shackleton is practically line for line identical

with the Fraunhofer spectrum as taken with the same instrument, with the addition of a slit and collimator, and thus the observation, first made by him visually in 1870, is now confirmed.

1898 *January* 21.—The preparations for this eclipse are already in progress, and the Joint Permanent Eclipse Committee hope to send out to India at least seven observers, who will occupy several stations along the line of totality. It seems that the chances in favour of fine weather are considerable, so that it is not likely that the unfortunate experiences of last year will be repeated. E. H. H.

Dr. Gill's Heliometer Observations.

From the Report of the Royal Observatory, Cape of Good Hope, it will be seen that the printing of the great work of Dr. Gill with the heliometer is well advanced. An early copy of volume ii. was presented to the Society in November, but it seems advisable to defer any notice of this very important work until next year, when it will be more completely published.

Mercury and Venus.

Observations made at the Lowell Observatory tend to confirm Schiaparelli's discovery of the equality of the periods of revolution round the Sun and rotation upon their axes for these planets. (See *Monthly Notices*, vol. lvii. p. 148.)

Lunar Theory.

During the past year a treatise on the Lunar Theory has been published by Prof. E. W. Brown, of Haverford College, U.S.A. The general aim of the work is to show clearly the correspondence between the theories of Laplace, de Pontécoulant, Hansen, Delaunay, and the new method with rectangular coordinates ; and the author has therefore given special attention to the relations which exist between the various forms of expression for the same function, and to the significations of the constants which arise in integrating the equations for disturbed motion. He has endeavoured, with considerable success, to simplify the methods of the above-mentioned writers, particularly those of Hansen. The treatise is professedly a text-book, but it contains much valuable work.

The Past Opposition of Mars.

The maximum apparent diameter of *Mars* at the late opposition was only about 17″, and during the most favourable period the planet's axis was nearly at right angles with respect to the Earth, so that the regions around both poles were un-

favourably placed for observation. The northern hemisphere generally, however, was better situated than it had been during the two previous apparitions. It is too early at present to give any complete account of recent observations of the surface marking of *Mars*, as opposition only occurred on December 11, but sufficient details have already come to hand to show that valuable results have been obtained, although few very startling changes seem to have occurred. Unfortunately the weather has been abnormally bad over England, even worse than it was in 1894.

The south polar snow cap seems again to have entirely disappeared, as in 1894, though this is not quite certain, on account of the polar regions having been unfavourably situated. The north polar cap re-appeared with all its characteristic brilliancy and whiteness as early as August 21, only thirty-eight days after the winter solstice of *Mars's* northern hemisphere. The observations show that the cap was irregular at this time, extending farther south at some places than at others.

Observations of irregularities at the terminator seem to have been rare during the past opposition, though a good instance of a bright projection was seen at the Lick Observatory on August 28, on or very near Chersonesus. Although no great instance of obscuration by cloud or fog like that of 1894 October occurred in 1896, yet some apparent changes recorded would seem to be due to the presence of cloud. In particular a whitish zone seen for several weeks at Juvisy surrounding the north polar cap, but not so brilliant as the true snow cap, has been ascribed due to this cause.

The system of dark streaks known generally as "canals" naturally constitutes at present one of the most interesting features in connection with *Mars*. This system, as laid down by Professor Schiaparelli, has received still further confirmation from recent observations. A considerable number of the canals discovered in 1894 at Mr. Lowell's observatory have also been confirmed, and many additional ones detected by various observers. Herr Brenner, at the Manora Observatory in particular, reports having seen as many as thirty-one canals not before recorded. This is no doubt due in great measure to the better position of the northern hemisphere for observation. But the network of canals has now attained to such complexity that it is no easy matter to be sure if a new canal has been seen before or not. This difficulty is increased by the fact that comparatively few of the original observations of the past three or four oppositions have yet been published, and, moreover, different observers seldom draw the existing canals exactly the same. An important feature of the recent observations is the further confirmation of the fact that certain canals vary enormously in appearance from time to time. As instances of this the Nepenthes and the canal named Ulysses by Mr. Lowell may be mentioned. The latter was as prominent as the Araxes, according to Professor Cerulli,

although in 1894 the Araxes had been *immensely* superior to the Ulysses. Nepenthes, on the other hand, seems to have been quite feeble lately according to observations by Messrs. Antoniadi and C. Roberts, although in 1894 it had appeared almost black and nearly as plain as the Cassini division of *Saturn's* ring when well open. Moreover, according to observations by Messrs. Antoniadi and Cerulli and at Mr. Lowell's observatory, the Kaiser Sea has recently actually encroached upon the continent nearly so far as Lake Mœris, so as to obliterate part of Libya.

Canals have been seen double during the past opposition by quite a number of observers. The double canals have, in fact, been more numerous than in either of the two previous apparitions, though not in such quantity as to necessarily support the theory that the gemination of the canals is essentially a seasonal change. The fact that the continental regions of *Mars*, to which the canals are chiefly confined, were better situated for observation, would account for a larger number being seen double. An important point in connection with the duplication of the canals is the liability of some of the small dark spots, or lakes, to become double likewise. A notable instance occurred recently in the case of the well-known spot, Trivium Charontis, which was seen double by Mr. H. F. Griffiths at Streatham on November 6, and independently as two circular black spots on November 10 by M. Antoniadi at Juvisy.

A great many delicate details have been seen and drawn by several observers in the large dark areas usually known as "seas," amongst them some narrow dark streaks having a close resemblance to the canals of the continental regions, and several narrow bright streaks, analogous to the well-known Atlantis of Professor Schiaparelli's map shown in part in Mr. Green's map as Noble Cape.

A. S. W.

Jupiter.

The appearance of the disk was found to be considerably altered when the planet became suitably placed for observation in the autumn of 1895. The "Red Spot" was faint, especially towards its central parts, which appeared almost as white as the south temperate belt. The most conspicuous markings were the two dark spots in the north tropical zone to which the names of the 'violin' and the 'garnet' spots have been given. These were, at first appearance, so dark and so sharply defined that they were mistaken by several observers for the shadows of satellites, but by the end of April they had both become exceedingly faint and difficult to measure. The period of rotation of the second of these has been determined by M. José Comas Sola as $9^h\ 55^m\ 33^s{\cdot}6$, while Professor Rambaut deduces a period of $9^h\ 55^m\ 33^s{\cdot}36$ for the same object. The longitude of this spot is given by Mr. Marth as expressed by the formula, $270°{\cdot}50 - 0°{\cdot}20\ (t - 1896\ \text{January}\ 21{\cdot}0)$.

From measures of photographs taken at the Lick Observatory Mr. A. Stanley Williams has deduced a period of $9^h\ 55^m\ 38^s{\cdot}9$ for spots lying between 40° and 85° north latitude. In a paper in the *Monthly Notices* for January he has also discussed most of the satisfactory determinations of the rotation period made up to that date, and points out that there are nine distinctly marked currents in the planet's atmosphere, which circulate in a due east and west direction, and show little or no movement towards or from the poles.

Dr. Belopolsky finds (*Ast. Nach.* No. 3326) that the equatorial velocity of the planet as determined by spectroscopic observations does not agree exactly with the value of this quantity deduced from the rotation of spots. His spectroscopic observations lead to a velocity of 11·4 kilometres per second in the line of sight, while the value deduced from the motion of spots is 12·1 or 12·8 kilometres per second according to the value assumed for the diameter. This discrepancy, he suggests, may be due to the refraction of light in the planet's atmosphere; but Deslandres' results, viz. V = 12·5, 11·9, 12·1, 11·7 do not support this conclusion. The result communicated to the British Association by Prof. J. E. Keeler is also at variance with Belopolsky's suggestion. From measurements made on four photographs, he finds $V = 12{\cdot}94 \pm 0{\cdot}27$, and points out that the velocity deduced from observations of this sort must be too small if the slit of the spectroscope does not exactly coincide with the equator of the planet.

The dimensions of the planet have engaged the attention of Messrs. Dyson and Lewis, at Greenwich Observatory, of Professor Schur, at Göttingen, and of Mr. Gledhill, at Bermerside, Halifax. Messrs. Dyson and Lewis have employed, in their investigation, both the filar and the double image micrometer, of which the filar micrometer seems to give the more consistent values, while those of the double image micrometer agree more closely with the heliometer results, the difference between the two amounting to about 1″ in each diameter. At the conclusion of his paper Professor Schur gives the following table containing the measures of *Jupiter's* diameters made in the neighbourhood of opposition with the larger heliometers :—

	A	B	$\frac{A-B}{A}$	Weight.
	″	″		
Bessel	37·66	35·24	1 : 15·6	2
Johnson	37·31	35·11	16·9	1
Winnecke	37·39	35·20	17·1	2
Main	37·14	34·94	16·9	1
Bellamy	37·19	35·02	17·1	1
Schur	37·42	35·10	16·2	2
Means ...	37·40	35·13	16·52	

In the *Bulletin Astronomique* for February will be found a continuation of Damoiseau's "Tables Écliptiques des Satellites de Jupiter," by Mons. L. Pottier. Damoiseau's tables stop at 1880 and have been continued by Adams to 1890, and by D. P. Todd up to 1900. In Mons. Pottier's paper Tables I. and III. are brought up from 1900 to 1920.

As is well known, Damoiseau's formulæ for the values of the arguments are not quite correctly derived from the fundamental data given on p. iii of his introduction. Corrections have accordingly been applied by Adams (Appendix to the *Nautical Almanac* 1881) to the arguments to make them consistent with the data and with each other. In the *Monthly Notices*, vol. lii. No. 8, Dr. Downing has published the corrected arguments. Mons. Schulhof has also calculated the correct values, but in his tables he prefers to use Damoiseau's values so that the calculation of eclipses before and after 1880 might be exactly comparable. Mons. Pottier has followed the same course in employing Damoiseau's slightly erroneous values, but he adds a table of the corrections which ought to be applied to the arguments according to Dr. Downing, and the greatest difference that these corrections could produce in the computed time of an eclipse for each of the four greater satellites.

The fifth satellite seems to have eluded observation; at least no account of such observations have come under our notice during the year. Towards the end of 1895 Professor Barnard secured some observations with difficulty. On 1895 December 3 the elongation was measured by him as $59''{\cdot}5$, which agrees well with Mr. Marth's ephemeris. The time of elongation was, however, $1^{m}{\cdot}6$ late by the ephemeris, which seems to show that the period adopted is slightly in error. It is still sufficiently precise, however, to enable the satellite to be found for several years.

A. A. R.

Tisserand's Mécanique Céleste, Vol. IV.

The last volume of this treatise was published during 1896, shortly before the sad and sudden death of its author. The first volume appeared in 1888, and was noticed in the Council Report for 1889 by the late Professor Adams, who commended it as "an elegant volume, forming the first part of an extensive treatise on the Mécanique Céleste. This valuable work is founded on the lectures which the author has given at the Sorbonne since 1883, first as the deputy, and afterwards as the successor of Mons. Puiseux. . . . As might be expected, the greatest attention to elegance is shown throughout in the exhibition of the mathematical formulæ, and the attractiveness of the work is much enhanced by the beauty of its typographical execution." These features have characterised the subsequent volumes, which appeared in 1890, 1893, and 1896.

It was the author's intention originally to complete the work in three volumes: the first dealing with planetary theory; the second with the figures and rotations of the heavenly bodies; and the third with the motions of satellites, including lunar theory and miscellaneous matters. But on approaching the last part of his work, he soon found that lunar theory would require a volume to itself, and vol. iii. was accordingly devoted to it. The present volume thus deals with the motions of satellites other than that of our Earth, comets, and miscellaneous matters. The first five chapters are occupied with *Jupiter's* satellites (excluding the fifth, which must be treated separately), in which the author follows Laplace and Souillart. In concluding a brief historical review of work on this problem, M. Tisserand modestly "thinks he may have succeeded in rendering more accessible one of the most beautiful theories of the Mécanique Céleste, which is essentially very simple, and only appears complicated because of a multiple notation which it is impossible to avoid." His labours will be amply repaid if they induce more people to read and work at the subject. It is, moreover, "much to be desired that a complete discussion of the observations should be made anew, as well as the determination of all the constants, including the velocity of light."

Chapters VI. to VIII. are devoted to *Saturn's* satellites. *Iapetus* is first considered, following earlier papers of M. Tisserand himself, and Dr. H. Struve's discussion of the observations. Next follows Professor Newcomb's work on the motion of *Hyperion*, with comments, and again a reference to Dr. H. Struve for a discussion of the observations; and finally an account is given of the beautiful discoveries of the last-named astronomer regarding the intimate connections of the motions of *Mimas* and *Tethys*, and again of *Enceladus* and *Dione*. There is very little to be said of the satellites of *Neptune*, *Mars*, and *Uranus*, which are dealt with in a single chapter. Indeed all the work on satellites only occupies 150 pages out of the whole 550. The remainder of the work treats of the perturbations of comets and their forms, and of the investigations of various kinds connected with minor planets, including brief notices of the work of Gyldén and Poincaré.

Double Stars.

As in the Report of last year, the work in this branch is treated of under two heads—observation and calculation.

Observation.—The measures published during the year 1896 are :—

Monthly Notices, Royal Astronomical Society, 1896 March.

(*a*) Of 19 southern doubles made with an 8-inch refractor by

Mr. John Tebbutt at Windsor, New South Wales, in 1895.

(*b*) Of 142 doubles made with the 28-inch refractor at the Royal Observatory, Greenwich, in the years 1894–5.

Astronomical Journal, 363.—Of 70 *Ophiuchi* in 1894 and 1895, by Schur, at Göttingen.

Ibid. 384.—Of 70 *Ophiuchi* in 1896, by See, at Lowell.

Ibid. 388.—Of 70 *Ophiuchi* in 1896, with 28-inch, at Greenwich.

Ibid. 389.—Of 70 *Ophiuchi* in 1896, by Leavenworth.

Ibid. 382.—Of 58 double stars in 1893, by Leavenworth, at Northfield.

Ibid. 391.—Of 85 *Pegasi* (*β* 733), by Schaeberle.

Astronomische Nachrichten, 3335.—Measures of double stars by the method of Interference, by Karl Schwarzschild, who places a disc with several parallel slits in front of the objective, as suggested by Michelsen.

Ibid. 3369.—Measures of 7 new and 55 old pairs made in 1895, by Mr. Sellors, at Sydney.

Ibid. 3378.—Measures by Dr. Doberck, at Hong Kong.

Astronomical Society of the Pacific.—Mr. Aitken's measures with the 12- and 36-inch telescopes at Lick in 1896.

Annales de l'observatoire de Paris.—Vol. xxi. contains the measures made by M. Bigourdan.

Journal of the B.A.A. vol. vi. No. 8.—A good set of 73 southern stars, made with a 5-inch at Shanghai by Mr. J. L. Scott in 1895.

The Observatory, 1897 January, and *Astronomical Journal*, 385 and 386.—On August 31 Dr. See announced that he had measured the companion of *Sirius* on its reappearance, but that the measures did not agree with the predicted place. Professor Schaeberle and Mr. Aitken afterwards measured an object which they took for the companion. These measures agreed with the ephemeris, and they were unable to see the object measured by Dr. See.

The places given

1896·678	220°·6	5″·07	See (24-inch)
1896·819	189·6	3·65	Schaeberle (36-inch)

Telegrams from Lick also announced that Professor Schaeberle had rediscovered the companion to *Procyon*, not seen since O. Struve's observations in 1873–4. He gives the place as position 318°, and distance 4″·6.

Calculation.—The orbits published during the year are given

below, with the periods, semi-major axes and eccentricities, and also a reference to the publication in which they appeared.

Star's Name.	Period (Years).	a	e	Reference.
β 733, 85 Pegasi	24·0	0·89	0·39	*A.N.* 3339
Σ 1728, 42 Comæ Ber.	25·6	0·64	0·46	*M.N.* 1896 June
β 416, Lac. 7215	33·0	1·22	0·51	*A.J.* 372
Σ 1937, η Cor. Bor.	41·5	0·89	0·28	*A.N.* 3370 (Doberck)
„ „	41·6	0·92	0·27	*A.N.* 3361
A.G.C. 1, Sirius	51·1	7·77	0·61	*A.N.* 3336
„ „	52·2	8·03	0·62	Stellar Systems (See)
OΣ 298	52·0	0·80	0·58	„ „
OΣ 38, γ^2 Andromedæ	54·0	0·37	0·86	*A.J.* 378
A.C. 15, 99 Herculis	54·5	1·01	0·78	*A.J.* 366
Σ 1196, ζ Cancri A.B.	60·0	0·86	0·34	*A.J.* 378
OΣ 234	63·5	0·34	0·36	Stellar Systems (See)
Σ 1967, γ Cor. Bor.	73·0	0·74	0·48	*A.J.* 376
α Centauri	75·6	18·17	0·52	*A.N.* 3330
„	81·1	17·70	0·53	Stellar Systems (See)
OΣ 235	80·0	0·87	0·32	„ „
Σ 2272, 70 Ophiuchi	87·7	4·55	0·50	*A.J.* 363
γ Centauri	88·0	1·02	0·80	*A.N.* 3339
OΣ 208, ϕ Ursæ Maj.	97·0	0·34	0·44	Stellar Systems (See)
Σ 1998, ξ Scorpii A.B.	104·0	1·36	0·13	„ „
Σ 1888, ξ Boötis	128·0	5·56	0·72	*A.N.* 3334
Σ 2729, 4 Aquarii	129·0	0·73	0·51	Stellar Systems (See)
Σ 518, 40 o^2 Eridani	167·0	4·16	0·07	*A.N.* 3366
„ „	176·2	5·22	0·22	*A.N.* 3306
Σ 1768, 25 Can. Ven.	184·0	1·13	0·75	Stellar Systems (See)
Σ 1760, γ Virginis	184·5	3·72	0·89	*A.N.* 3364
Σ 2032, σ Cor. Bor.	370·0	3·82	0·54	*A.N.* 3339

A.N. = *Astronomische Nachrichten.* *A.J.* = *Astronomical Journal.*
M.N. = *Monthly Notices*, R.A.S. Stellar Systems (see below).

Beyond the actual calculation of orbits, the work done includes :—

Monthly Notices, 1896 June.—A paper by Miss Everett, entitled "Galactic Longitudes and Latitudes of Poles of Binary-Star Orbits," in which is a most useful list of double-star orbits, with the positions of their poles. No decided tendency to favour any special region of the sphere is shown.

Astronomische Nachrichten, 3336.—H. F. Zwiers gives a new method of computing a double-star orbit, and applies it to calculate the orbit of *Sirius*.

Popular Astronomy.—Professor Burnham, in a paper on "The Binary Systems," analyses his catalogue of double stars (which to N.P.D. 120° contains 10,940 pairs), and divides them into groups of binaries with good orbits, with doubtful orbits, certain binaries, probable binaries, rectilinear, &c.

In the same publication he discusses the orbits of *Castor* and *τ Ophiuchi*, showing that we must not put too much faith in the calculated orbits.

Astronomical Journal, 378.—Dr See gives a complete list of the 40 orbits computed by him.

The Observatory, *No.* 242.—Dr. Doberck gives a method for correcting double-star measures for refraction.

Ibid. 237.—Mr. Lewis has a note on Σ 305.

Ibid. 238.—Mr. Lewis draws attention to Σ 1074 and Σ 1500.

Researches on the Evolution of the Stellar Systems, vol. i., by T. J. See.—In this volume, which he has published with commendable promptitude, Dr. See has collected his many papers on double stars to form what we may call the body of the work, which he has prefaced by a history of double-star astronomy, and a general review of methods of determining orbits, with an exposition of Kowalsky's method. A final chapter is devoted to preliminary deductions from this mass of material, chief of which are: (1) Double-star orbits have high eccentricities, and on the average twelve times those found in the planetary system, and this extraordinary result is evidently the expression of a fundamental law of nature. (2) The stars of a system are comparable, and frequently almost equal, in mass.

The volume is evidently intended to set forth the materials on which a future research, on the lines of tidal friction as indicated by Darwin, is to be based; but apart from this, it will always serve as a useful reference-book for observers.

T. L.

Chandler's Third Catalogue of Variable Stars.

Mr. Chandler published his First Catalogue in 1888 (*Ast. Journ.* Nos. 179–180), it being then thirteen years since the appearance of Schönfeld's Second Catalogue of Variable Stars, and the need of a catalogue representing the knowledge of the time being thus urgent. In 1893 Mr. Chandler published his Second Catalogue (*Ast. Journ.* No. 300), in which the first was corrected and revised to date, and definitive elements of every star (in the sense that all available observations to date were

used in the calculation) were given. In the introduction to the Third Catalogue, published in 1896 (*Ast. Journ.* No. 379) we read: "Since the appearance of the Second Catalogue, it has been the endeavour to keep pace with the rapid accumulation of new material by the occasional issue of supplements. The time appears now to have arrived when a new edition of the Catalogue is necessary, incorporating everything up to date. . . . The construction of the present Catalogue is in every respect similar to that of the Second Catalogue."

Mr. Chandler remarks with satisfaction on the fact that very few stars in the northern hemisphere have been neglected during the last few years, although there has been no organised attempt at cooperation. "In the southern hemisphere particularly the need for volunteers is pressing."

Dr. Auwers' Zone Catalogue.

In portioning out different parts of the heavens to different observatories for the formation of its well-known catalogue the Astronomische Gesellschaft allotted to Berlin Observatory the zone lying between 14° 50′ and 25° 10′ north declination. This zone was again divided by Dr. Foerster into two, of which the northern half was assigned to Dr. Becker, and the southern to Dr. Auwers. Then Dr. Auwers, with the assistance of Dr. Romberg to read the circle, working with the old transit circle of the Berlin Observatory (4 inches aperture and 3 feet circle, divided to every 2′ of arc), between 1869 February and 1871 August made 22,028 observations of 9,789 stars, exclusive of 2,822 observations of fundamental stars, and this part of the work was finished. Thus it took $2\frac{1}{2}$ years to make the observations, but the reduction and publication of the results have taken nearly 25 years. In order to accelerate the rate of observation, only one microscope was read, and a correction applied to reduce the reading to the mean of the four microscopes usually read. The equator point was determined by three successive approximations, and the final reductions were made to the epoch 1875. A number of systematic corrections have been applied to the observations, but the general results seem satisfactory. The method adopted in reducing the right ascensions was similar to that adopted for the declinations, with the addition of the following novel correction for personality depending on the star's magnitude :—

Mag.	Corr. s	Mag.	Corr. s	Mag.	Corr. s
8·8	·000	9·1	−·031	9·4	−·073
8·9	−·009	9·2	−·044	9·5	−·089
9·0	−·020	9·3	−·058	9·6	−·106

As part of the programme laid down by the Astronomische Gesellschaft, a comparison with older catalogues and a determination of proper motions were included in the scheme. Needless to say, Dr. Auwers has exhausted all available material for the zones under his charge in such discussions, and deduced systematic corrections to the whole of the catalogues involved, entailing a prodigious amount of work. For 1,300 stars in the zone Dr. Auwers has found proper motions, some of which may be open to question. Among them are some of Bradley's stars, the proper motions of which Dr. Auwers had previously determined, but the corrections are usually under $^{s}\cdot001$ and $''\cdot001$ in R.A. and Dec. respectively. In addition to these data, interesting discussions and tables are appended, dealing with the number and distribution of the stars with different proper motions, and an analysis of their average relation to magnitude. The amount of work and figures involved in this book must have been enormous, and the value to be attached to the results can best be gauged by the fact that the responsibility rests on the shoulders of Dr. Auwers, supported by Dr. Romberg, Dr. Battermann, Professor Küstner, Dr. Lamp, Dr. Harting, and Dr. Stumpe.

W. G. T.

A Photometric Catalogue of the Southern Stars.

Though we have become accustomed to see large masses of work produced in a comparatively short space of time by Professor E. C. Pickering and those associated with him in his labour, it is impossible to under-estimate, through familiarity with his methods, the amount of photometric work which Professor S. I. Bailey accomplished during his residence in South America in 1889–91. A scheme which proposed the photometric determination of the magnitude of 7,922 stars, involving as it did some 19,000 measures, would be considered an enormous undertaking if it were not dwarfed to some extent by the amount of photometric work which Professor Pickering has already published. But in contrasting the work of the Southern Observatory with that of Harvard, it would be very unfair to Professor Bailey not to take into account the different circumstances and surroundings under which the work has been accomplished. Professor Bailey was far from the conveniences and support of scientific life. Every difficulty, as it arose, had to be met and overcome by his resourceful energy and ingenuity. He had to rely on his own judgment, knowing that all material assistance was thousands of miles distant. That he succeeded in carrying his instruments to three separate stations without any injury to his equipment, often on the backs of mules and along roads which he himself improvised, tells as much for his care and foresight as the amount of work which he accomplished speaks of his energy and perseverance.

The object of the expedition was to extend to the southern hemi-

sphere the photometric investigations undertaken at Cambridge, and consequently to secure on a uniform plan the magnitudes of all the brighter stars in the sky. With this view the larger of the two meridian photometers that had been in use at Harvard was sent to South America under the charge of Professor Bailey, who had familiarised himself with the use of the instrument in its original position. With this instrument it was proposed that he should measure the brightness of all stars in the following catalogues :—

1. All stars in the *Uranometria Argentina* whose magnitude is given as 6·2 or brighter.
2. All stars in the catalogue of Behrmann's *Atlas des südlichen gestirnten Himmels* described as brighter than the 6th magnitude.
3. All stars in Houzeau's *Uranométrie Générale* except those whose magnitude is given as 6 or 6·7.
4. All stars of the Harvard Photometry south of $-30°$ declination.

This part of the programme is practically an extension of the Harvard Photometry given in vol. xiv. of the *Annals*. To this list were added all those stars from the *Argentine General Catalogue* which lie in a series of zones, twenty minutes wide, whose mean declinations for 1875·0 were $-25°, -30°, -35°$, . . . up to 80°, while all stars in a zone of twice the width were to be included whose magnitudes exceeded the eighth. Certain other stars possessing unusual interest were also added, making a total of 7,922 stars.

Professor Bailey first selected a station near Chosica, in south latitude 11° 52′, and at an elevation of 6,600 feet. Here a small observatory was erected, wherein was located the Bache Telescope for photographic work, in addition to the photometer ; and the work was steadily pursued under a sky which permitted an almost uninterrupted view of the stars. The number of stars observed in a single night more frequently exceeded than fell short of a hundred, and on one occasion no less than 292 stars were observed in 398 minutes. When the rainy season came on, and this excessive activity was no longer possible, Professor Bailey sought for a more congenial site in a lower latitude. Here, at Pampa Central (lat. $-23°$ 10′), he accomplished the record feat of observing no less than 302 stars on a single night, and the condition of the station is shown generally by the fact that observations were possible on 33 nights out of the 43 during which he remained there. From this station Professor Bailey returned to Chosica, where the third section of the work was carried on, and finally removed to Arequipa, which town had been selected by Professor Pickering as the position for the permanent establishment of a branch observatory. In 1891 May Professor Bailey, having finished the task with which he had been entrusted, handed over the charge of the observatory to

Professor W. H. Pickering, and he himself returned to Harvard, taking the meridian photometer with him.

It is perhaps far too early to speak of the degree of accuracy that the observations made under such unusual circumstances possess. The agreement of the results between themselves is in this instance a particularly untrustworthy criterion. The circumstances under which the photometer was used differ considerably from those that obtained at Harvard, where a thorough and unflinching criticism has been applied to the observations. At Chosica, as at Harvard, the image of the star whose magnitude was sought has been compared with that of a polar star. But while at Harvard the polar star had a zenith-distance never greater than about 49°, at Chosica the comparison star would have a zenith-distance of about 78°, and at the most southern station would not be more than about 28° above the horizon. Under these conditions the effects of atmospheric absorption are very different from those at Cambridge. The effect is not so important on an individual star as on the standard star with which a whole night's work is compared. The derivation of the correction on account of atmospheric absorption demands such an increase of observation that one might well doubt whether the meridian photometer is the best adapted for the work to which it was applied. Professor Pickering, aware of the difficulties, arranged his plan of observations accordingly, and has applied methods of reduction which are apparently successful ; but for a full description reference must be made to the volume itself. There are, however, anomalous circumstances which seem to imply either that the nights devoted to photometric work were not always suitable, or that the processes of reduction still leave something to be desired. For instance, there are several nights in which the computed value of the atmospheric absorption is *negative*. This would imply that a star near the horizon appeared brighter than when at the zenith, and on some occasions by no inconsiderable quantity. Such results have not been rejected as impossible, but have generally been retained, though it is a question if the final accuracy is increased by the incorporation of such observations.

The magnitudes of the brighter stars have been formed into a catalogue (containing 1,428 stars) with approximate coordinates for 1900, and reference numbers to other well-known catalogues, such as Stone, the Argentine Uranometry, etc. Also the magnitudes estimated by Houzeau and others have been inserted for comparison. This is the practical extension of the Harvard Photometry to the whole sky, and is probably the most accurate part of the work, as the observations are usually more numerous and the chance errors consequently better distributed. Also the instrument, with its aperture of 10·5 cm., is better adapted to measure the light of the stars which enter into this catalogue than of others, verging on the tenth magnitude and even feebler, which appear in other parts of the work.

W. E. P.

The Cape Photographic Durchmusterung.

In 1885 Dr. Gill commenced a photographic survey of the heavens from Decl. $-18°$ to the S. Pole. He secured the cooperation of Dr. Kapteyn, who undertook the measurement and reduction of the photographic plates. The first instalment, which has just appeared, extends from Decl. $-18°$ to $-37°$, and contains over 150,000 stars. The photographs are taken with a rapid rectilinear Dallmeyer lens of 6 inches aperture and 54 inches focal length. Each plate covers 6° by 6° of the sky, and the centres of the plates are about 5° apart on parallels of declination 5° distant. They are taken in duplicate to eliminate the risk of setting down accidental specks as stars.

The exposures are regulated by the condition that a photograph of any selected region should show all the stars given by Argelander, and vary from one hour to thirty minutes, according to the quality of the nights and sensitiveness of the plates employed.

The machine with which the plates are measured, designed by Dr. Kapteyn, gives the right ascensions and declinations directly. All measures are made in duplicate, the discordances, omissions, &c. being examined by Dr. Kapteyn himself. The right ascensions and declinations are reduced to the epoch 1875·0; their probable error is given as $\pm 0^{s}\cdot27$ and $\pm 2''\cdot6$ respectively. Great attention is given to the identification of the stars, and references are given as far as practicable—it being inconvenient to print more than five for one star—to the catalogues in which the stars occur, along with their visual magnitudes. Lists are also given of the brighter stars which occur in various southern catalogues, and are not found on the photographic plates.

The magnitudes are obtained by comparison with the stars on the plates whose visual magnitudes are given in Schönfeld's *Durchmusterung* or Gould's *Zone Catalogue*, thus making the mean photographic magnitude correspond with the mean visual magnitude. The formula employed connecting the magnitude with the diameter is, magnitude $= \frac{B}{\text{diameter}+C}$. The average number of stars per square degree is 25·4, and varies from 6 to over 100, according to proximity to the Milky Way. In the *Bonn Durchmusterung* the number of stars is 15·2 per square degree, and in Schönfeld's *Durchmusterung* is 18·5. It is of interest to compare the *Cape Durchmusterung* with Dr. Thome's *Cordoba Durchmusterung*, of which an account was given in the Report of the Council in 1894 February, as these were made almost simultaneously, one by photographic methods, and the other visually.

	Decl.	No. of Stars.	No. per Sq. Degree.	Probable Errors.	
				s	″
Cordoba	$-22°$ to $-42°$	340,000	56·1	±0·42 in R.A.	±13·8 in Decl.
Cape	$-18°$ „ $-37°$	152,000	25·4	±0·27 „	± 2·6 „

The scale of magnitudes in these two surveys is compared by Dr. Kapteyn, who also discusses the variations between visual and photographic methods depending on the distance from the Milky Way.

F. W. D.

The Astrographic Chart.

The fourth *réunion* of the Comité Permanent was held in Paris in May. The reports furnished by the directors of the co-operating observatories show that satisfactory progress has been made in two-thirds of them. Owing to political or financial difficulties, the work has not yet begun at Santiago de Chili, La Plata, and Rio Janeiro, and is seriously hampered at several other observatories.

The following table shows how far the photo-mapping has advanced in the different zones :—

	Zone.	No. of Fields Assigned.	No. taken for Cat.	No. taken for Chart.	
Greenwich	+90 to +65	1,149	728	472	213 plates measured ; 102 plate constants determined
Rome	+64 „ +55	1,040	280	100	—
Catania	+54 „ +47	1,008	21	None	—
Helsingfors	+46 „ +40	1,008	1,008	A few	160 plates measured and partly reduced
Potsdam	+39 „ +32	1,232	500	„	35,000 stars measured
Oxford	+31 „ +25	1,180	800	None	40,000 stars measured on 160 plates
Paris	+24 „ +18	1,260	1,155	Not stated	318 plates measured, 60 reduced
Bordeaux	+17 „ +11	1,260	300	60	Measures to be begun soon
Toulouse	+10 „ + 5	1,080	150	350	70 plates measured
Algiers	+ 4 „ − 2	1,260	1,000	64	168 plates measured with 32,000 stars
San Fernando	− 3 „ − 9	1,260	1,260	about 400	50 plates measured once and 25 twice
Tacubaya	−10 „ −16	1,260	529	Not stated	Measuring to begin soon
Santiago de Chili	−17 „ −23	1,260	—	—	—
La Plata	−24 „ −31	1,360	—	—	—
Rio Janeiro	−32 „ −40	1,376	—	—	—
Cape of Good Hope	−41 „ −51	1,512	1,512	Nearly half	30 plates measured
Sydney	−52 „ −64	1,400	1,393	1,112	—
Melbourne	−65 „ −90	1,149	703	A few	—

Examination of this table shows that (omitting altogether the three South American Observatories which have not yet

commenced) the taking of the catalogue plates is generally well advanced, and that some progress has been made with the chart plates. The measurement and reduction of the catalogue plates has been begun by more than half the observatories, and considerable progress has been made by six or seven of them.

The Congress first turned its attention to the degree of accuracy which it was desirable to obtain in the measurement of the photographs. It was decided that the probable error of the measured coordinates ought not to exceed $\pm 0''.20$.

The choice of the reference-stars and the methods of measurement and reduction were left to the discretion of the directors of the cooperating observatories. It was resolved that the measured rectilinear coordinates should be published as soon as possible, along with the necessary data for obtaining the right ascension and declination of the stars when required. With regard to the magnitudes, the Congress laid down no conditions except that the methods adopted for their determination should be capable of precise definition, so that the scales employed at different observatories might be readily comparable. For the Chart it was decided that in the odd zones a triple exposure of 30^m should be given.

Captain Abney undertook to supply the different observatories with scales which should be printed on the plates at the same time as the *réseau*, and supply a measure of the sensibility of the plates for light of different intensities. It was also resolved that two positives of each chart-plate should be made on glass, and that one of them should be placed in the Bureau National des Poids et Mesures.

Several papers have appeared during the year, exemplifying the methods adopted at various observatories (*e.g.* Paris, Helsingfors, Greenwich) for the determination of plate constants, and the accuracy which may be obtained from the measures on the catalogue plates.

It is our sad duty to record the death of the President of the Comité Permanent, M. Tisserand, the distinguished Director of the Paris Observatory.

F. W. D.

The International Conference on Fundamental Stars.

It has long been recognised as a desideratum in practical astronomy that the adopted places of stars as given in the astronomical ephemerides of different nations should be deduced from a uniform system of fundamental places, and from a uniform system of elements of reduction. The advantages of such a step are sufficiently obvious, and, as the time seemed almost ripe for the carrying out of the project, correspondence on the subject took place during the course of the year 1895 between the Directors of the National Ephemerides of America, England, France, and Germany. The matter was warmly taken up

by the *Bureau des Longitudes*, and it is mainly due to the exertions of that learned body that the necessary preliminaries were arranged in such an entirely satisfactory manner. In the event it was decided to hold an International Conference in Paris at the close of the meeting of the Astrographic Congress, which had been fixed for the month of May, 1896. Each of the Directors of the four great National Astronomica Ephemerides mentioned above was authorised to nominate a colleague, who would be invited to attend the Conference ; and Dr. Gill was specially invited to attend as representing the observatories in the southern hemisphere. The *personnel* of the Conference was definitely arranged as follows :—

America ...	...	MM. Backlund and Newcomb
England ...	...	Christie and Downing
France ...	...	Loewy and Tisserand
Germany ...	...	Auwers and Bauschinger
S. Hemisphere	...	Gill.

Professor van de Sande Bakhuyzen and M. Trépied attended as consultative members of the Conference, and undertook the secretarial duties.

M. Faye, the learned and venerable president of the *Bureau des Longitudes*, was nominated President of the Conference, and occupied the chair at the opening meeting. On subsequent occasions the chair was taken by M. Loewy, the vice-President of the Conference. MM. Auwers and Christie were unable to attend the meetings of the Conference.

The following resolutions were adopted, after ample discussion and with practical unanimity :—

1. For the general fundamental catalogue the equinox should be determined solely from the observations of the Sun, excluding those of *Mercury* and *Venus*.

The absolute correction of the right ascensions of the system called N_1 (*i.e.* that of the catalogue of 1,098 equatorial and zodiacal stars published in vol. i. of the *Astronomical Papers of the American Ephemeris*) being very small, it was decided that this correction should be neglected, or, in other words, that the equinox of the system N_1 should be adopted.

2. In view of the uncertainty that still exists with regard to the numerical value of the personal error depending on magnitude, which affects the right ascensions of stars, it was decided that corrections for these errors should not be applied in the ephemerides.

But as the existence of such personal errors cannot be doubted, the Conference considered that the observatories should undertake researches necessary for the determination of their numerical values.

3. On the point as to whether the century should be adopted as the unit of time for the first term of precession, as well as for the secular variation, the Conference left it to those who would be

entrusted with the duty of constructing the fundamental catalogue to select the form of expression that appeared to them to be most convenient.

4. The Conference entrusted to Professor Newcomb the duty of determining the definitive values of the luni-solar and planetary precessions.

Professor Newcomb undertook to finish this work within a year.

5. The Conference recommended the following values of the astronomical constants named :—

Nutation	$9''.21$
Aberration	20·47
Solar parallax	8·80

6. With regard to the reduction of mean to apparent places of stars, it was decided :—

a. That the term of short period in right ascension

$$f' = -0''.1866 \sin 2\odot + 0''.0622 \sin(\odot - \Gamma'),$$

which has the same value for all stars, should be omitted in the ephemerides for polar as well as for equatorial stars.

b. That all the other terms of short period should be omitted in the ten-day ephemerides, but retained in the cases of polar stars, the apparent places of which are given for every day.

c. That these same terms of short period should be omitted in the ephemerides of the Sun and planets.

7. Professor Newcomb was entrusted with the duty of preparing a provisional fundamental catalogue in accordance with the system adopted by the Conference. All details that had not been definitely settled should be discussed by correspondence. The catalogue should be finished within a year.

The Conference regarded it as a matter of the highest scientific importance that Professor Auwers should continue his researches, so as to complete his definitive fundamental catalogue.

8. The Conference expressed the hope that each star of the common fundamental catalogue should appear at least once in one of the four ephemerides—viz. *American Ephemeris*, *Berliner Jahrbuch*, *Connaissance des Temps*, and *Nautical Almanac*.

9. It was considered desirable that a common catalogue of zodiacal stars should be adopted, and that the positions of the provisional fundamental catalogue should be taken as its basis ; that the distribution of the stars of the zodiacal catalogue should be in accordance with Dr. Gill's proposals ; and that the observation of these stars should be particularly recommended to the observatories.

10. The Conference expressed the hope that a scheme of international co-operation might be established for the calculation of the perturbations and ephemerides of minor planets.

11. The Conference expressed the opinion that a first-class

reversible instrument, suitable for fundamental determinations, should be erected in one of the observatories of the southern hemisphere.

12. The decisions of the Conference, in so far as they refer to changes in the values of astronomical constants, should take effect in the ephemerides for the year 1901.

In order to carry out the decisions of the Conference, Professor Newcomb has been busily engaged since his return home on the construction of the provisional fundamental star catalogue, which will contain the places of about 1,000 stars. The initial epoch of the catalogue is 1875. The *Bureau des Calculs* of the *Connaissance des Temps* and the *Nautical Almanac* Office, aided by the assignment to it by the Admiralty of a sum of money for the purpose, are about to undertake in concert the computation of the reduction-elements necessary for bringing up the catalogue places to 1900. There appears, therefore, every reason to expect that the catalogue will be ready in good time, and that astronomers may look forward to the inauguration of a new era in the history of astronomical ephemerides at the commencement of the twentieth century.

A. M. W. D.

Professor Rowland's Preliminary Table of Solar Spectrum Wavelengths.

Professor H. A. Rowland has continued during the year the publication of his "Preliminary Table of Solar Spectrum Wavelengths," which he commenced in the number of the *Astrophysical Journal* for 1895 January. The Tables published in 1895 carried the spectrum from λ 3722 well in the ultra violet to λ 5914 in the orange. Those published last year completed the visible spectrum down to λ 7331, and have commenced the region of the extreme ultra violet at λ 2976, and brought it down to λ 3260, the calculations of wavelengths in this region not having been completed at the time when publication was first commenced.

This, the fullest catalogue of the solar spectrum yet attempted, contains in the Tables which have so far appeared some sixteen thousand lines. The wavelengths have been determined from measurements made by Mr. L. E. Jewell of Professor Rowland's photographs of the solar spectrum, and are reduced to wavelengths in air at 20° c. and 760 mm. pressure.

The intensities of the lines are given in numbers from 1 to 1,000, it being quite rightly decided that the ordinary scale from 1 to 10 is far too limited in range.

Lines seen with difficulty are indicated by one or more zeros according to the faintness of the line. The wavelengths are expressed in tenth-metres and to the third place of decimals. A

large number of lines are referred to the element producing them, the spectrum of every known element except gallium having been photographed at the Johns Hopkins University in connection with the solar spectrum. The measurement of these plates will, however, occupy several years, so that the identification of the lines will receive much greater extension in the future.

It must, under the most favourable circumstances, be a considerable time before the work is completed, so the author has wisely determined to publish this preliminary table of the solar lines, leaving it to be added to or corrected at a future time until the final list can be compiled.

When we bear in mind the number of spectroscopic theories that have been based on imperfect and erroneous observations, we shall be able readily to appreciate the enormous service that Professor Rowland has rendered, firstly, by the construction of his unrivalled ruling-engine ; and secondly, by the excellent use to which he has put the beautiful gratings thus obtained.

The expenses of this great fundamental work have been partly borne by grants from the three following funds :—The Bache fund of the National Academy of Sciences, the Rumford fund of the American Academy of Sciences, and the Bruce fund of Harvard College Observatory.

Spectroscopic Astronomy in 1896.

Oxygen in the Sun.—Professors Runge and Paschen have recently succeeded in resolving a line in the extreme red of the spectrum of oxygen, discovered by Professor Piazzi Smyth. The line appears to consist of three components, apparently coinciding with three lines of the same relative intensity in the solar spectrum. From such evidence as is at present available, these lines do not appear to be due to the influence of our own atmosphere, and therefore may be supposed to have a true solar origin.

Water-vapour in the Atmosphere.—Mr. L. E. Jewell has carried out systematic observations of the region of the "rain-band" for the purpose of ascertaining the value of the spectroscopic method for determining the quantity of water-vapour in the air. Observations were made both by eye and by photographic means, but the latter method was soon discontinued as unsuitable, and reliance placed on the eye-observations alone. Mr. Jewell concludes, in disagreement from the earliest workers on the "rain-band," that observations made with small spectroscopes, or by pointing a spectroscope towards the sky instead of towards the Sun, are of little or no use. Nor is the spectroscope of great value for weather predictions. Its great use is for the study of the distribution of water-vapour in the atmosphere.

Water-vapour in the atmosphere of Mars.—Professor W. W. Campbell has criticised in considerable detail the early observations which appeared to point to the presence of water vapour in the Martian atmosphere, concluding that they were insufficient to demonstrate its presence. Mr. Jewell also urges that the means hitherto used for this purpose have been utterly inadequate, and that nothing could be determined with regard to the presence of water-vapour in the atmosphere of *Mars* unless its amount was much greater than in that of the Earth. The presence of oxygen might possibly be detected by observations made at a considerable elevation.

Two new spectroscopic Binaries.—Two of these interesting objects have been discovered during the year in the examination of the Draper Memorial photographs. The first is μ_1 *Scorpii*, a first type star with the additional lines characteristic of the *Orion* group. The period appears to be $34^h\ 42^m{\cdot}5$, and the orbit to be circular. The second is Lacaille 3105, A. G. C. 10534. The period in this case is nearly the same as of β *Aurigæ*, being $3^d\ 2^h\ 46^m$. The only other spectroscopic binary yet known, ζ *Ursæ Majoris*, has a much longer period, being one of about fifty-two days.

Zeta Puppis.—The spectrum of this star as described by Mrs. Fleming from the Draper Memorial photographs appears unlike any other as yet obtained. The continuous spectrum is traversed by three systems of lines : first, dark lines, of hydrogen with the K line ; next, two bright lines, which may be identical with two characteristic lines of stars of the fifth type ; and, thirdly, a set of six lines forming a rhythmical series not known in any element with which we are yet acquainted.

Stellar Motions in the Line of Sight.—A number of suggestions have been made recently for enabling the objective prism to be used in the determination of the motion of stars in the line of sight. Hitherto it has been the one great objection to this instrument that it was not available for this research. In 1895 Professor Orbinsky pointed out that the recession of a star involved a contraction in the distance in the interval between two distant lines in the photograph of a stellar spectrum obtained with an objective prism, and he proposed, by photographing two or more spectra side by side, to make the measures differential and not absolute. M. Deslandres proposes an apparatus by which a comparison spectrum might be obtained at the same time as the spectrum of the star. Mr. Maunder has suggested the measurement of the total deviation of a ray by photographing the spectrum of a star, the objective prism being used, and then removing the prism to photograph the star itself on the same plate, reading the angle between the two positions of the telescope by means of an accurate declination circle. Professor E. C. Pickering has worked out another method applicable for determining the relative motions of two or more stars near enough to be photographed upon the

same plate, the distance between the same line in the two spectra being shortened if the violet end of the spectrum of the more rapidly approaching star is directed towards the other spectrum.

Hitherto none of the suggested methods have seemed perfectly suitable, but from the earnest attention which the question is now receiving, it may be hoped that it will not be long before the problem is finally solved.

A New Star in Centaurus.—Circular No. 4 of the Harvard College Observatory announced the discovery of a *Nova* in the constellation *Centaurus*. It was found by Mrs. Fleming on examining some of the Draper memorial photographs, taken at Arequipa. No trace of it could be found on the fifty-five plates taken from 1889 May 21 to 1895 June 14, but its magnitude was 7·2 on plates taken on 1895 July 8 and 10. In December of the same year it had sunk to the 11th mag. It was discovered from the peculiarity of its spectrum, as taken on July 18; its spectrum resembling that of the nebula surrounding 30 *Doradus*, and of the star *A.G.C.* 20937. Its spectrum, as examined visually on December 19, was monochromatic, and closely resembled that of the adjacent nebula *N.G.C.* 5253. Its approximate position for 1875 is *R.A.* $13^h\ 32^m\ 51^s{\cdot}8$, *S. Dec.* 30° 59′·58.

Geodesy.

During the past year H.M. Astronomer at the Cape has published his Report on the Geodetic Survey of South Africa, the work of which was done by Colonel Morris, R.E., C.M.G., Lieutenant Laffan, and a party of Engineers, during the years 1883–92, under the direction of Dr. Gill.

The expense of this survey was borne jointly by the Governments of Cape Colony and Natal. The survey which, thanks to Dr. Gill's persistence, is of the nature of a contribution to scientific geodesy rather than a mere effort in map-making, consists of the measurement of base lines at Natal, Port Elizabeth, and Kimberley, and triangulation which connects these, and with them the base line measured by Sir T. Maclear in Zwartland in 1841, the length then found being adopted without change. The line of triangulation follows the coast line pretty closely from Natal to Port Elizabeth, thence to Cape Town and northward almost as far as Orange River. The Kimberley base line is connected with that at Port Elizabeth by a line of triangulation approximately north and south, and this line is connected with that along the west coast by a line from Hanover to Calvinia. There is a further tie-chain joining this last line with that along the south coast, and the triangulation in Natal is extended northward from the base, which is fourteen miles from Pietermaritzburg, to the northern boundary of the colony and eastward to Durban.

The base lines were measured by means of five 10-foot measuring-bars, which were compared with the Cape 10-foot

standard bar A, previously used by Sir Thomas Maclear. This standard bar, by the courtesy of the Comité Internationale des Poids et Mesures, was compared with the Règle Géodésique No. 2 in charge of that institution, so that the absolute lengths of this survey are comparable with those of European surveys. The Natal base, which is of 10,800 feet, was first measured, and was divided into three sections ; the lengths of the two outer sections were derived in terms of the middle by triangulation, and the close agreement between the lengths of these outer sections thus determined with their measured lengths led Dr. Gill to decide that the measurement of long base lines was not an absolute necessity, and therefore for the Port Elizabeth and Kimberley bases lengths of 5,600 and 6,000 feet only were measured, which were extended by triangulation to about 17,058 feet and 14,760 feet respectively.

It would be beyond the scope of this note to follow the work and its reduction in detail. It may suffice to say that in the final tables of results the adjusted angles and lengths of the sides of all the triangles are given, and incorporated with them are the similar quantities found by Maclear in his survey of 1841–1848, which have been adjusted to the system of the present circuit. From these are computed the latitudes and longitudes of all stations, and the azimuths of all lines, the latitude and longitude of Buffelsfontein, and the line Buffelsfontein to Zuurberg being taken as the origin of these. Clarke's elements of the figure of the Earth were used for this computation. Besides the triangulation, as above described, astronomical observations for latitude were made at nineteen stations, of azimuth at twelve stations ; and the differences of longitude between eight stations and the Cape Observatory transit-circle were determined telegraphically. These astronomical results are compared with the geodetic (it should be mentioned that the longitude of Buffelsfontein above referred to was deduced from that of the Cape Observatory from the triangulation), and the discussion of this comparison leads to some interesting remarks by Dr. Gill. Dr. Gill is not satisfied that the astronomical longitude results, which were obtained by members of the staff of the Cape Observatory in co-operation with Colonel Morris, are all free from systematic error due to variation of personal equation, and in the case of two best determined arcs, the astronomical and geodetic values differ by about $4\frac{1}{2}''$; but by using Airy's elements of the figure of the Earth, instead of Clarke's (a convenient table is computed for making this change) this difference is reduced to about $1''$. There are similar differences between the geodetic and astronomically determined latitudes, sometimes as large as $10''$, but the substitution of Airy's for Clarke's elements has little effect on these. Dr. Gill thinks that these discordances arise from local attraction, " where the contour of the Earth's surface would lead to the expectation that no deviation of the plumb line would be found," and his experience gained from this work leads him to think that a

desideratum in any survey is the multiplication of stations at which astronomical observations are made.

Dr. Gill, Col. Morris, and all concerned are to be congratulated on the completion of their labours, which is the first contribution to Geodesy in the southern hemisphere, if we except Maclear's somewhat limited survey in verification of Lacaille's meridian arc, and probably the first step in an accurate survey of the whole of the African continent.

Another recently published work on this subject is by General J. T. Walker, R.E., C.B., F.R.S., a former superintendent of the Indian Trigonometrical Survey, whose death occurred in February last. This memoir, entitled *India's Contribution to Geodesy*, appeared in the *Philosophical Transactions* for 1895, and is a history of the Great Indian Trigonometrical Survey and *résumé* of results from its beginning in 1800, to the present time. There are various notes on the instruments used, and tables of their probable errors. Latitudes and longitudes are computed from the results of the triangulation with Col. Everest's elements of the Earth, and also with Col. Clarke's latest determination, which are compared with the astronomically determined latitudes and longitudes. The comparison goes far to show the superiority of Clarke's elements. In the section on astronomical longitudes, there is an instructive account of a certain discordance found in determinations of time, when made in the two positions of reversible transit instruments, which led to large circuit errors in the longitude results. The cause of this discordance was ultimately traced to an imperfection in the method of determining the collimation error. The differences of latitude determined geodetically and by astronomy, and the difference of lengths of geodetic and astronomical longitude arcs, show some remarkable effects of abnormal local attraction. The deviation of the plumb line at Dehra Dûn, for instance, causes a discordance of about two seconds of time in the longitude. Finally, General Walker derives from the accumulated data eight meridional arcs, of amplitude ranging from 2° 24′ to 3° 38′, freed from the effects of local attraction with their corresponding lengths in feet, and four longitude arcs, two of about 24° 49′ amplitude, almost free from local deviation with their corresponding lengths. Of these results, he says in his concluding paragraph: "The eight meridional and the two longest longitudinal arcs here given are believed to be the most valuable contribution to Geodetic science that has yet been made. They are the results of operations which have been carried on in India during a period of over ninety years, with more or less vigour at different times, but always with the cordial support and approval of the Government of India."

H. P. H.

New Observatories.

On 1896 April 7 the new Royal Observatory, Edinburgh, was formally opened by Lord Balfour of Burleigh, Secretary of State for Scotland.

This building on the Blackford Hill replaces the observatory on Calton Hill originally established by a small body of scientific gentlemen of Edinburgh in 1811 with the help of the Edinburgh Town Council, which was taken over by the Crown as a Royal Observatory in 1834. In 1889 the Earl of Crawford presented to the Edinburgh Observatory the astronomical library and the collection of instruments which had formed the equipment of his observatory at Dunecht, and it was decided by the Government that these should be housed in a building on a site better fitted for observation than Calton Hill, where the atmosphere had become unsuitable owing to the growth of the city. The new site was chosen on Blackford Hill ; the Town Council made a grant of land, and at the same time relieved the Government of the care of the Calton Hill building, which is to be utilised as a popular observatory ; and the Government voted 30,000*l.* for the building. The plans were made by, and carried out under the direction of, Mr. W. W. Robertson, of H.M. Office of Works ; and the result is an observatory magnificently adapted for its purpose, which may be described shortly as consisting of two domes, 100 feet apart, with a terrace between. The chief instruments at present are the 15-inch refractor formerly belonging to Lord Crawford, and the 24-inch reflector made by the firm of Grubb for Professor Piazzi-Smyth.

It was expected that the inauguration ceremony of the Yerkes Observatory would have taken place last autumn ; but delay in the building prevented this. The observatory is, however, nearly completed. The staff of this institution, which is a branch of the Chicago University, consists of the Director, G. E. Hale, S. W. Burnham, E. E. Barnard, and F. L. O. Wadsworth.

Two other American Universities are said to be adding Practical Astronomy to their scheme of work. The University of Ohio, Columbus, is setting up an observatory with a refracting telescope of 12 inches aperture ; and the University of Illinois, Champaign, is also providing a similar building, with a telescope of the same aperture.

An observatory, whose present work is to be the study of variable stars and stellar photometry generally is to be established at Rössgen, Mittweida, Saxony, under the direction of Dr. Friedrich Krueger.

Mr. Percival Lowell has removed his observatory from Flagstaff, Arizona, to a hill about three miles north of the City of Mexico.

H. P. H.

The Adams Memorial.

In the autumn of the past year, 1896, within a few weeks of the fiftieth anniversary of the discovery of *Neptune*, there was published the first volume of the Collected Scientific Papers of the late Professor John Couch Adams.

This volume, to quote the words of the preface, "contains all the original papers which were published by him during his lifetime, extending from 1844 (when he was 25 years of age) to 1890"—in all 62 papers.

A biographical notice is prefixed to the volume (pp. xv.–xlviii.) and has been written by Dr. Glaisher. A great part of it is devoted to a statement of the facts relating to the memorable discovery of *Neptune*. The task has been accomplished with admirable fairness and tact and lucidity. Dr. Glaisher gives so vivid an account of the sequence of events that the reader lives through the time again, sharing the warm feeling of a past generation, forming his own opinion afresh, and justifying the judgment which has been passed by all nations. Two notes of historical interest are reproduced in *facsimile*—Adams' memorandum of his intention of investigating the irregularities in the motion of *Uranus*, and the note which he left at Greenwich in 1845 October, giving the results of the success of his analysis in the search for an exterior planet. Challis's first report to the Cambridge Observatory Syndicate is also printed in full. The portrait of Adams which forms the frontispiece is the engraving by Stodart from the photograph by Mayall.

The papers are arranged not chronologically, but as far as may be according to subject-matter. The papers relating to *Neptune* and *Uranus* naturally come first. Next follow notes about comets, the orbit of γ *Virginis*, the total eclipse of 1851 (which Adams himself went to observe), and papers relating to planetary and lunar tables. The memorable paper, "On the Secular Variation of the Moon's Mean Motion," published in 1853, is followed by other papers on lunar theory, ranging between the date just mentioned and 1888. Next comes the paper on the orbit of the November meteors. As we turn over the pages of the volume we realise anew how much of Adams' work has passed into the history of astronomy.

In the publication of this volume and in the distribution of copies to learned societies at home and abroad, another part of the Adams Memorial has been completed, and we understand that the second volume is so far forward that it is possible to foresee that a sum of about 200*l.* will remain to be offered to the Master and Fellows of St. John's College, Cambridge, to form an exhibition fund for the encouragement of the study of mathematics and physics by the undergraduate students of the college.

Universal Time.

In the Report of the Director of the Natal Observatory, published during the past year, it is stated that the official time of the colony is now that of the thirtieth meridian east of Greenwich, and that the Time Signal is now sent from the observatory at 1 o'clock Natal Uniform Time, which corresponds to $11^h\ 0^m\ 0^s$

Greenwich Civil Time. From articles in colonial newspapers, it appears that there is some feeling that this time system should be adopted for the whole of South Africa. At present the time used in Cape Colony, the Transvaal, and Orange Free State is $1\frac{1}{2}$ hour fast on that of Greenwich.

Since 1895 January 1 Mid-European time (1 hour fast on Greenwich) has been in use in Norway, so that the list of countries where the time is that of the Greenwich meridian, or differs from it by an integral number of hours, is now: Great Britain, Belgium, Holland, Denmark, Norway, Switzerland, Italy, Germany, the colony of Natal, all the Australian colonies, Japan, the United States, and Canada.

It is believed that Mid-European time is also used on the railways of Sweden and in several towns in Austria (Vienna is not one of these); also that in Bulgaria, Roumania, and European Turkey, East European time (2 hours fast on Greenwich) is used; but there is no information that this is the legal time of these countries.

At the latter end of 1896 the suggestion was raised in the French Chamber of Deputies that the time of the Greenwich meridian should be adopted throughout France. The matter was referred to a committee, the majority of whom were in favour of the proposal.

It may be added here, though this does not fall within the scope of the above heading, that on and after May 1 next the standard time of Belgium will be reckoned from 0 to 24 hours, that is, the hour immediately following noon will be numbered 13 instead of 1, as at present.

H. P. H.

Papers read before the Society from March 1896 to January 1897.

1896.

Mar. 13. Note on the indexing of scientific papers. H. Seward.

Description of a spectroscope (the Bruce spectroscope) recently constructed for use in connection with the 25-inch refractor of the Cambridge Observatory. H. F. Newall.

Observations of the variable star R. *Carinæ* from 1890 December to 1895 August. J. Tebbutt.

Discovery and observations of comet *Brooks* (*d.* 1895). W. R. Brooks.

Observations of the variable stars *W*, *X*, and *Y Sagittarii*. Lieutenant-Colonel E. E. Markwick.

Elliptical orbit elements of comet *b* 1894 (Gale). Rev. T. Roseby.

Results of double-star measures with the 8-inch equatorial at Windsor, New South Wales, in 1895. J. Tebbutt.

On the relative efficiency of a reflector and of portrait-lenses for the delineation of celestial objects. Isaac Roberts.

Observations of comets made at the Royal Observatory, Edinburgh.

Note on Mr. Stone's paper "Expressions for the elliptic co-ordinates of a moving point to the seventh order of small quantities." E. W. Brown.

Fireball of 1895 November 22. W. F. Denning.

On the systematic errors of measures on photographic plates. H. H. Turner.

Note on a curious light (the zodiacal light ?) as seen at Oxford, 1896 March 4. H. H. Turner.

Variation of *T Centauri*. A. W. Roberts.

Results of micrometer measures of double stars made with the 28-inch refractor in the years 1894 and 1895, at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

A graphical method of solving Kepler's equation. H. C. Plummer.

Note on the sensibly-cylindrical forms of the pivots of

Mar. 13. the transit-circle of the Radcliffe Observatory, Oxford. E. J. Stone.

Note on the zodiacal light of 1896 March 4. W. H. Robinson.

Note on Professor Turner's paper on the systematic errors of measures of photographic plates. W. H. M. Christie and F. W. Dyson.

Observations of comet *a* 1896 (Perrine-Lamp) made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

On the proper motions of certain fundamental stars. W. G. Thackeray.

Apr. 10. Note on Professor Brown's note. E. J. Stone.

Occultation of *Jupiter*, 1893 February 20, observed at the Durham University Observatory.

Errata to paper on meridian observations of *Sirius* and *Procyon* made at the Royal Observatory, Greenwich. W. G. Thackeray.

Note on the solution by least squares of the equations arising in the reduction of photographic star-plates. H. Jacoby.

Ephemeris for physical observations of *Mars*, 1896–97. A. Marth.

Observations of comet *a* 1896 (Perrine-Lamp) made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

Some notes on the use and adjustments of the cœlostat. H. H. Turner.

May 8. Researches on the orbit of 42 *Comæ Berenices*=Σ 1728. T. J. J. See.

Further note on the light seen at Oxford on 1896 March 4. H. H. Turner.

Diameters of *Jupiter*, measured with the filar and double-image micrometers at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

Ephemeris of the satellites of *Mars*, 1896–97. A. Marth.

Photographs of the spectra of twenty-three characteristic helium stars; also photographs of the spectra of six stars of the third magnitude, showing the transitions from type to type. F. McClean.

Observations of comet *a* 1896 (Perrine-Lamp) and *b* 1896 (Swift), made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

June 12. Observations of phenomena of *Jupiter's* satellites with the $9\frac{1}{3}$-inch Cooke equatorial refractor at Mr. Crossley's Observatory, Bermerside, Halifax, in 1895–96. J. Gledhill.

On certain phenomena presented by *Jupiter's* satellites and their shadows during transit; with a note on the

June 12. red spot, and on some methods of observing the transits of bright and dark spots across the central meridian. J. Gledhill.

Measures of the polar diameter and of the principal belts, and of two dark spots on *Jupiter*; and of satellites and their shadows in transit, made at Mr. Crossley's Observatory, Bermerside, Halifax, during the apparition of 1895–96. J. Gledhill.

Note on the period of *T Centauri*. A. W. Roberts.

Occultations of certain stars in *Præsepe* by the Moon on 1896 October 1, visible at Greenwich. Communicated by the Superintendent of the *Nautical Almanac* Office.

Cometary observations at the Liverpool Observatory in 1895. W. E. Plummer.

Galactic longitude and latitude of poles of binary star orbits. Alice Everett.

On the proper motion of B. D. +25°, No. 2874. W. W. Bryant.

An answer to certain questions asked in the *Bulletin Astronomique*, tome xiii., mai 1896, on time measurement. E. J. Stone.

Solar eclipse without instrumental means. E. J. Stone.

Note on a possible eclipse of *Jupiter's* second satellite by the shadow of the third, 1896 March 30. A. C. D. Crommelin.

Observations of comet *b* 1896 (Swift), made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

Meridian observations of comet *b* 1896 (Swift) at lower transit, made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

On the corrections to the right ascensions of stars derived from observations of the Sun made at Greenwich during the years 1836–95. W. G. Thackeray.

On the equipment of the astrophysical observatory of the future, with two appendices: Appendix I. On the support of large specula; Appendix II. On making the siderostat an instrument of precision. G. Johnstone Stoney.

Nov. 13. On the importance of accurately observing the *Leonids* this year. G. Johnstone Stoney.

On the comparison of reflector and portrait-lens photographs. E. E. Barnard.

Ephemeris for physical observations of *Jupiter*, 1896–97. A. Marth.

Data for computing the positions of the satellites of *Jupiter*, 1896–7. A. Marth.

Observations of comets and planets, made with the

Nov. 13. 15-inch Dunecht refractor and wire micrometer at the Royal Observatory, Edinburgh.

Observations of the phenomena of *Jupiter's* satellites at Windsor, New South Wales, in the year 1896. J. Tebbutt.

The Sidereal System : revised in 1896. Maxwell Hall.

Mercury. P. Lowell.

Determination of the rotation period and surface character of the planet *Venus.* P. Lowell.

Remarks on the physical observations of *Jupiter*, made at the Adelaide Observatory, 1884–93. E. P. Sells.

On the variation of uncanonical arbitrary constants ; with an application to the planetary theory. A. Y. G. Campbell.

Mean areas and heliographic latitudes of Sun-spots in the year 1894, deduced from photographs taken at the Royal Observatory, Greenwich, at Dehra Dûn (India), and in Mauritius. Communicated by the Astronomer Royal.

Observations of comet *f* 1896 (Perrine), made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

Note on the effects of distance upon the spectra of physical clusters of stars. E. J. Stone.

Observations of comet Perrine, 1896 Nov. 2, made at the Radcliffe Observatory, Oxford.

Photographic stellar spectra of the variable star β *Lyræ*, and also of types III. and IV. F. McClean.

Observation of comet Perrine 1895 IV., made at the Radcliffe Observatory, Oxford.

Dec. 11. Report on the expedition to Japan to observe the total solar eclipse of 1896 August 9. W. H. M. Christie, E. H. Hills, and H. H. Turner. Communicated by the Joint Permanent Eclipse Committee.

Report on the expedition to Norway to observe the total solar eclipse of 1896 August 9. A. A. Common. Communicated by the Joint Permanent Eclipse Committee.

Report to the Joint Permanent Eclipse Committee on the expedition to Kiö Island. J. Norman Lockyer. Communicated by the Committee.

Real paths of 101 meteors observed during the ten years ending November 1896. W. F. Denning.

Catalogue of real paths of large meteors. G. von Niessl.

Ephemeris for physical observations of the Moon, 1897. A. Marth.

Observations of minor planets made at Windsor, New South Wales. J. Tebbutt.

Comparison of the Sun's longitudes for 1901, computed from Newcomb's tables of the Sun, with those computed from Le Verrier's tables. A. M. W. Downing.

Dec. 11. Ephemeris of the *Leonids*, with introductory remarks. G. Johnstone Stoney.

On systematic errors in observing right ascensions of nebulæ. J. L. E. Dreyer.

The aurora of 1896 March 4. T. W. Backhouse.

Observation of Brooks' periodic comet, *c* 1896 (1889 V.), made at the Radcliffe Observatory, Oxford.

Observations of the solar eclipse, 1896 August 8–9, at Novaya Zemlya. E. J. Stone. Communicated by the Joint Permanent Eclipse Committee.

Observations of comet *f* 1896 (Perrine), made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

On the inequality in the diurnal movement of stars due to refraction, and a method of allowing for it in astronomical photography. A. A. Rambaut.

Observations of the *Leonids* on 1896 Nov. 13 and 14. A. A. Rambaut.

1897 Jan. 8. Observations of the *Leonids*, made at the University Observatory, Oxford.

A method of clearing a lunar distance. F. C. Penrose.

Determination of the diameter and compression of the planet *Mars*, from observations with the Repsold heliometer of the Royal Observatory, Göttingen. W. Schur.

On the comparison of reflector and portrait lens photographs. Isaac Roberts.

Orbit of 44 Boötis $\frac{H}{\delta}$ I. 15=Sh. 193=Σ 1909. S. W. Burnham.

Note on the magnitude of η *Argûs*, 1896. R. T. A. Innes.

Heliographic co-ordinates of Sun-spots and faculæ on the Stonyhurst drawings. A. L. Cortie.

Note on Mr. A. Y. G. Campbell's paper "On the variation of uncanonical arbitrary constants, with an application to the planetary theory." Sir R. S. Ball.

On differential refraction to terms of higher order than the first. H. H. Turner.

Observations of comet 1896 I. (Perrine-Lamp), made at the Radcliffe Observatory, Oxford. Communicated by E. J. Stone.

Notes on meteors observed at Penarth, Glamorgan, on 1896 November 14. G. C. Thompson and H. W. L. Tanner.

Observations of occultations of stars by the Moon, and phenomena of *Jupiter's* satellites, made in the year 1896, at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

List of Public Institutions and of Persons who have contributed to the Library, &c., since the last Anniversary.

Her Majesty's Government in India.
The Lords Commissioners of the Admiralty.
The French Government.
The Italian Government.
The Norwegian Government.
British Association for the Advancement of Science.
British Astronomical Association.
British Horological Institute.
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London Mathematical Society.
Meteorological Office.
Physical Society of London.
Royal Geographical Society.
Royal Institution of Great Britain.
Royal Meteorological Society.
Royal Observatory, Greenwich.
Royal Photographic Society of Great Britain.
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Cambridge Philosophical Society.
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Dublin, Royal Irish Academy.
Dublin, Royal Society.
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Rugby School Natural History Society.
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Adelaide Observatory.
Amsterdam, Royal Academy of Sciences.
Arcetri, Royal Observatory.
Athens, National Observatory.
Australasian Association for the Advancement of Science.
Baltimore, Johns Hopkins University.
Batavia, Magnetical and Meteorological Observatory.
Batavia, Royal Society of Natural History.
Belgium, Royal Observatory.
Berlin, Central International Geodetic Bureau.
Berlin, German Transit of Venus Commission.
Berlin, Physical Society.
Berlin, Royal Astronomical Computation Institute.
Berlin, Royal Observatory.
Berlin, Royal Prussian Academy of Sciences.
Berlin, Royal Prussian Geodetic Institute.
Berne University.
Bologna, Royal Academy of Sciences.
Bombay Branch of the Royal Asiatic Society.
Bombay Government Observatory.
Bordeaux, Society of Physical and Natural Sciences.
Boston, American Academy of Arts and Sciences.
Brisbane, Royal Geographical Society of Australasia.
Brussels, Astronomical Society of Belgium.
Buda-Pesth, Hungarian Academy of Sciences.
Buda-Pesth, Royal Hungarian Institute for Meteorology and Terrestrial Magnetism.
Buenos Aires, Argentine Meteorological Office.
Calcutta, Asiatic Society of Bengal.
Calcutta, Surveyor-General of India.
Canada, Geological Survey.
Cape of Good Hope, Geodetic Survey of South Africa.
Cape of Good Hope, Royal Observatory.
Cape Town, South African Philosophical Society.
Catania Observatory.
Chicago, Academy of Sciences.
Coimbra Observatory.
Copenhagen, Royal Danish Academy of Sciences.
Cordoba, Argentine National Observatory.
Cracow, Academy of Sciences.
Dorpat, Imperial University Observatory.
Georgetown College Observatory.
Göttingen, Royal Society of Sciences.
Halifax, Nova Scotian Institute of Sciences.

Halle, Imperial Leopold-Caroline Academy.
Harvard College Astronomical Observatory.
Helsingfors, Geographical Society of Finland.
Helsingfors, Society of Sciences of Finland.
Hongkong Observatory.
Italian Meteorological Society.
Kalocsa Observatory.
Karlsruhe Observatory.
Leiden Observatory.
Leipzig, Astronomical Society.
Leipzig, Prince Jablonowski Society.
Leipzig, Royal Society of Sciences of Saxony.
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Lisbon, Royal Observatory.
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Madrid Observatory.
Madrid, Royal Academy of Sciences.
Manila Observatory.
Mauritius, Royal Alfred Observatory.
Melbourne Observatory.
Melbourne, Royal Society of Victoria.
Moscow, Imperial Society of Naturalists.
Munich, Royal Bavarian Academy of Sciences.
Naples, Academy of Physical and Mathematical Sciences.
Natal Observatory.
O-Gyalla, Central Meteorological and Magnetical Observatory.
Ottawa, Royal Society of Canada.
Padua Observatory.
Padua, Royal University.
Paris, Academy of Sciences.
Paris, Astronomical Society of France.
Paris, Bureau of Longitude.
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Paris Observatory.
Paris, Philomathic Society of France.
Paris, Polytechnic School.
Philadelphia, American Philosophical Society.
Philadelphia, Franklin Institute.
Pola, Meteorological and Magnetical Observatory.
Prague, Imperial Observatory.
Rio de Janeiro Observatory.
Rome, Central Meteorological Office.
Rome, Italian Spectroscopic Society.
Rome, Pontifical Academy *dei Lincei*.
Rome, Royal Academy *dei Lincei*.
St. Petersburg, Astronomical Society of Russia.
San Francisco, Astronomical Society of the Pacific.
Stockholm, Royal Swedish Academy of Sciences.

Strassburg, Imperial University Observatory.
Sydney, Royal Society of New South Wales.
Tacubaya, National Astronomical Observatory.
Tasmania, Royal Society.
Tiflis, Physical Observatory.
Toronto, Astronomical and Physical Society.
Toronto, Canadian Institute.
Toronto University.
Toulouse, Academy of Sciences.
Turin, Royal Academy of Sciences.
Upsal Observatory.
Vienna, Austrian Geodetic Commission.
Vienna, Imperial Academy of Sciences.
Vienna, Imperial Ministry of Marine.
Vienna, von Kuffner Observatory.
Virginia, Leander McCormick Observatory.
Washburn Observatory of the University of Wisconsin.
Washington, National Academy of Sciences.
Washington, Office of the American Ephemeris.
Washington, Philosophical Society.
Washington, Smithsonian Institution.
Washington, United States Coast and Geodetic Survey.
Washington, United States Naval Observatory.
Yale University Astronomical Observatory.
Zurich, Central Meteorological Institute of Switzerland.
Zurich, Natural History Society.
Editors of the "American Journal of Mathematics."
Editors of the "American Journal of Science."
Editor of the "Astronomical Journal."
Editor of "Astronomische Mittheilungen."
Editor of the "Astronomische Nachrichten."
Editors of the "Astrophysical Journal."
Editor of the "Athenæum."
Editors of the "Bulletin des Sciences Mathématiques."
Editor of the "English Mechanic."
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ADDRESS.

Delivered by the President, A. A. Common, LL.D., F.R.S., on presenting the Gold Medal to Professor E. E. Barnard.

Your Council have this year awarded the Gold Medal of the Society to Professor Edward Emerson Barnard, for his discovery of the fifth satellite of *Jupiter*, his celestial photographs and other astronomical works, and, according to custom, it becomes my pleasant duty to state more fully the circumstances that have influenced the Council in making this award.

[Before proceeding with his address the President expressed his deep regret that Professor Barnard was not present at the meeting. He had left New York on February 2 in order to be present on this occasion, but his ship, the *Trave*, had not yet arrived, and the fact that other Atlantic liners were overdue made it probable that there had been some rough weather causing the delay. As events proved, this surmise was correct, the *Trave* reaching Southampton after midnight the same night, February 12.]

The discovery of the fifth satellite of *Jupiter* (certainly the most important discovery of the last twenty years) is the product of three factors—a good telescope, a good sky, and a good observer. To the munificence of James Lick the telescope on Mount Hamilton is due, and, without detracting in the slightest degree from the credit that is due to Professor Barnard for his magnificent discovery, a large share of honour remains to James Lick and the maker of the telescope, George Alvan Clark. Without this particular combination of men it is not too much to say that the fifth satellite would yet remain to be discovered. We may congratulate our medallist on having the opportunity of using the Lick telescope, and we may certainly also congratulate the donor and the maker on having secured an observer like Professor Barnard to do justice to the telescope. Though since its discovery it has been seen by other observers in America and a few in England, yet, as was pointed out by Sir John Herschel, the difference between seeing an object already known to be there and discovering that object is very great, and, moreover, although the satellite has been seen by others, with the exception of Hermann Struve at Pulkowa, they have been unable

to measure its position. Our knowledge of its orbit is due almost entirely to the observations of Professor Barnard himself. I do not know that I can demonstrate the magnitude of Professor Barnard's especial achievement more clearly than by calling to mind that his friend, Professor S. W. Burnham, our medallist of three years ago, had shared with him the advantages of telescope and climate for some years, and yet the satellite remained unknown.

To us the news of the discovery was announced from Mount Hamilton in the following telegram :—"Professor Holden announces that the Lick telescope has revealed the existence of a fifth satellite to *Jupiter* with a period of $12^h\ 36^m$. Its distance from the centre of the planet is 112,400 miles, and its light compares with that of a star of the thirteenth magnitude," published on 1892 September 13 (the satellite having been discovered on September 9), which was followed by a later telegram, informing us that Professor Barnard had made the discovery, and placing the period at $17^h\ 36^m$. The confusion that arose from these telegrams was not cleared up till about October 16, by the receipt of the *Astronomical Journal* of October 4, No. 275, in which Professor Barnard gives an interesting account of his discovery of this satellite, with the measurements he had made.

From the elongations he deduced a period of $11^h\ 49^m{\cdot}63$, but as this was only from measurements obtained between September 9 and 14, it was, of course, only a first, but, considering the extreme difficulty of the object, a very close approximation. Later observations made by Professor Barnard have enabled the period to be better determined at $11^h\ 57^m\ 22^s{\cdot}60$.

He has given a most interesting account of his discovery and a diagram showing the relative size of the satellite as compared with the other four. He estimates the diameter at about the $\frac{1}{300}$th part of the diameter of *Jupiter*, and states that a magnification which raised the other four satellites to veritable moons failed to increase the diameter of the fifth. This little body stands quite by itself in the Jovian system. In the recently published volume iv. of his *Mécanique Céleste* our late lamented Associate, M. Tisserand, remarks that the theory of its motion must be discussed quite apart from those of the other four, whose movements it is probably too small to influence seriously. Had it been larger, and our knowledge of the motions of the other four more completely worked out, it is conceivable that we might have got some suspicion of its presence from theoretical considerations, but it is noteworthy that neither in this way nor in any other was the actual discovery led up to. In the case of *Hyperion* there was a marked gap in the already complex Saturnian system which suggested the possibility of another satellite, but we had become so thoroughly accustomed to the well-established Jovian system that it must have required a positive effort to conceive the possibility of an addition to it, and

in this way I regard the discovery of Professor Barnard as most remarkable.

I have alluded to the discovery of *Hyperion*; and, in fact, our minds, on such an occasion as the present, naturally turn to others of the same character.

Besides the fifth satellite of *Jupiter*, our century has produced six new satellites, of which four belong to those red-letter years 1846 and 1847, which added to the solar system *Neptune* and his satellite, two new satellites of *Uranus* and one (*Hyperion*) of *Saturn*. William Lassell, who had the whole credit of two of these discoveries, and a share in that of the others, received our medal in 1849 from the hands of Sir John Herschel "for the construction of his equatorial instrument and the discoveries made with it." The prominence given to the construction of the instrument bears out what I have already ventured to say above. In his presidential address, Sir John Herschel quoted an official report to the following effect:—"The simple facts are that Mr. Lassell cast his own mirror, polished it by machinery of his own contrivance, mounted it equatorially in his own fashion, and placed it in an observatory of his own engineering; that with this instrument he, a private man, of no large means, in a bad climate, discovered the satellite of *Neptune*, the eighth satellite of *Saturn*, and re-observed the satellites of *Uranus*."

Thirty years elapsed before any more new satellites were brought to our knowledge, and then Professor Asaph Hall (aided by the same constructive skill as that which enabled our present medallist to make his brilliant discovery, that of the Alvan Clarks) announced the two satellites of *Mars*. In 1879 he received our Medal for this great achievement from the hands of Lord Lindsay, now Lord Crawford. It is by the side of these men—one an Englishman, of whom we are justly proud, and the other a fellow-countryman of his own, in whom he doubtless has a similar national pride—that Professor Barnard now takes his place; and, in recognition of his right to this place, your Council has conferred upon him the highest honour in its power. Although the number of satellite discoveries credited to these three men shows a progressive decrease from four to two and from two to one (a minimum which it is, however, impossible to further reduce in the future), the quality of the achievement must on the other hand progressively rise; for it may be confidently asserted that each new discovery is harder than those preceding it. Moreover, our present medallist has other claims of an equally high character on the respect and admiration of astronomers. The terms of the formal award include his photographs and other astronomical work. But before passing to these I will venture to follow the example set by Lord Lindsay on the occasion to which I have already referred, in giving some account of the life of the man whom we hoped to have seen among us to-day. Lord Lindsay remarked that Mr. Asaph Hall's early history afforded "a bright example of what per-

severance and determination may effect in overcoming even the most adverse circumstances," and this is equally true of our present medallist. Indeed, when we consider the life-histories of astronomers who have become famous, we cannot but be struck with their general similarity. In so many cases they have become astronomers, not through the action of outside forces, but very often in spite of them, and simply from their own determination. Professor Barnard's early life, as described* by his friend, S. W. Burnham, is like that of many other notable astronomers, but with every turn accentuated to a degree almost romantic.

He was born at Nashville, Tennessee, in 1857. His early education was limited to two months' attendance at a common school, and such instruction as his excellent mother could give him at home. Fatherless and destitute at the close of the war, he began at the age of eight or nine to work in a large photographic studio in Nashville, and soon became a faithful and accomplished assistant to his employers. The loan by a friend of Dr. Dick's book, the *Practical Astronomer*, in 1876, awakened a love for astronomy which soon grew into a passion. The use of a 1-inch cheap lens roughly mounted in a tube of his own construction showed him something of what a telescope would do; and the visit of a travelling showman to Nashville, with a small glass for street exhibition, further stimulated him to acquire as good an instrument as he could for himself. Accordingly, by practising the most rigid economy he was enabled in 1877 to purchase a 5-inch telescope, and it is significant that his first systematic work of any importance was a careful study of the planet *Jupiter*. In 1881 he began to search for new comets with his 5-inch, and discovered one on September 17 of that year. This was followed a year after by another, and in 1884 he found a comet of period 5·4 years. The next year, 1885, yielded two new comets, 1886 one, and 1887 three more; and in the five succeeding years he found altogether eleven comets, one of them (1892 V.) being another new comet of short period (6·30 years). One notable result of this success was that he several times obtained the prize of 200 dollars offered by Mr. Warner for the discovery of a new comet, and was thus enabled to buy books and other accessories and to pursue his studies with fewer financial anxieties.

In 1883 he left the photographic business, having received a Fellowship in Astronomy at the Vanderbilt University. During the preceding years he had given all his spare time to study, working in the daytime and studying alone at night. It is easy to mention these facts in a few words, but not so easy to give an idea of all that they mean—the continuous and courageous struggle against adverse circumstances of all kinds. He now utilised to the full the opportunities afforded by the University in the time he spared from the hard work at the 6-inch equa-

* *Popular Astronomy*, and *Harper's Magazine*, September, 1893.

torial, which resulted in the cometary discoveries above mentioned, and in many others, such as new nebulæ and double stars. To one of these last I shall refer presently.

In 1888 he was offered a position in the Lick Observatory, then about to be opened with the largest equatorial in the world, in a climate of which Professor Barnard is wont to speak with an almost reverent enthusiasm ; and the able way in which he availed himself of these advantages is now familiar matter of history. With one notable exception (that of the Sun) every description of celestial object has come under his scrutiny, and his skill as an observer is only equalled by his skill as a photographer. And after thus briefly reviewing his career, I now return to his work, and especially to his photographs, which are definitely mentioned in the terms of the award of the Medal.

The astronomical photographs which Professor Barnard has made are chiefly of comets and of the Milky Way, taken with the " Willard " lens of the Lick Observatory, having an aperture of 6 inches and a total length of 31 inches. These latter are perhaps the finest examples of star photography extant. Moreover, they are the *first photographs* made to show the structure of the Milky Way. Many observers have made eye investigations on the distribution of the stars in the Milky Way. Amongst others we may note those elaborate representations of the galaxy south of 12°·5, which became accessible in 1877 by the Atlas of the *Uranometria Argentina* of Dr. Gould and his assistants at Cordoba, followed by the elaborate map which Dr. Boeddicker prepared at Lord Rosse's observatory. These, with the drawing by Mr. Trouvelot, and the earlier drawing made by Sir John Herschel at the Cape of Good Hope, represent the attempts made to delineate the Milky Way by the pencil, and any one working at the distribution of stars in the Milky Way will naturally use these drawings for comparison.

Personally I have little doubt of the essential inferiority of the drawings to the photographs, and, though it may be of some interest to know the points of difference, I cannot but think that photographs such as those of Professor Barnard are the only safe ground in such an investigation.

With regard to the comet photographs, our medallist has the credit of having made the first discovery of a comet by photography, an event which, of course, was bound to come sooner or later, but for which full credit may freely be granted to the first in the field. The series of photographs of comets taken by Professor Barnard, showing, as they do, the rapid changes that take place in comets' tails, are of great value. He has also actually obtained meteor trails on his photographic plates. Exposing plates on 1890 August 9, 10, and 11, he got traces of the trails of meteors, and on one of the plates of Brooks' Comet, taken on 1893 November 13, there is a very fine trail of a meteor. Finally, with a small lens of short focus,

Professor Barnard discovered the great nebula surrounding the belt of *Orion*.

We have in the library of this Society some sixty glass photographs presented by Professor Barnard, positive copies made with his own hands of some of his photographs. An inspection of these beautiful pictures, which are, I trust, well known to most of us, will reveal their merits far better than any description I can give, and I will offer but one further remark on the photographic work of our medallist. In the case of his discovery of the fifth satellite, we saw that there were at least three important factors, without any one of which success could not have been attained. But in the photography of our medallist, and in much of his other work, the external factors have less significance, and the results may be claimed almost entirely by the observer himself. Professor Barnard has shown us with what modest means good results can be obtained—with not only a small but a cheap lens, such as may be found in any magic lantern. No doubt his early experiences, of which I have spoken, were valuable in giving him this knowledge of what can be done with humble apparatus ; but we must certainly admire, not merely the skill, but the courage of a man who could, under the very shadow of the great 36-inch refractor, demonstrate the merits of a lens which could be bought for a few shillings.

Such a demonstration we might have naturally awaited from a man whose instrumental equipment was necessarily small, or who could not use a large telescope to advantage ; that it should come from Professor Barnard, who had not only the opportunity of using the great refractor, but conspicuous ability for such work, is proof not only of his untiring industry, but of his thoroughly unprejudiced mind.

To summarise the other work of our medallist is a matter of some difficulty, owing to its enormous amount and its varied character. Up to the end of last year he had published twenty-six papers in the *Monthly Notices*, eighty-five in the *Astronomische Nachrichten*, seventy-five in the *Astronomical Journal*, and seventy-four in other American papers connected with astronomy, including an important report on the eclipse of 1889 January 1, published by the Lick Observatory. These represent, in nearly every case, work done at the telescope, and show him a brilliant and untiring observer of the very first order. I shall make no attempt at completeness, but shall merely endeavour to illustrate his extraordinary keenness in observing and his versatility ; and as a first illustration, I will mention his independent discovery in 1883 of that singular phenomenon called the "Gegenschein." This was discovered many years ago by a German astronomer, though its cause is still a mystery, and even now but few astronomers, though they know what to look for, have ever seen it. That our medallist should have independently discovered it, having no knowledge of it previously, is testimony to observing skill of the highest quality ; and the fact that he himself, as I understand,

estimates the discovery as a piece of his very best work is in itself very significant. In the same year he accomplished a unique performance in double-star astronomy. Noticing that the star *β Capricorni* disappeared at occultation by the Moon, not instantaneously, but gradually, he had sufficient confidence in his observation to ask for scrutiny of this star with the most powerful instruments available, and ultimately, with the 18½-inch equatorial of the Dearborn Observatory at Chicago, his friend S. W. Burnham found the star to be a close and unequal double, which, as Professor Burnham himself remarked, "taxed the powers of that splendid instrument to show even to a trained eye."

To the cometary discoveries of our medallist already mentioned, it must be added that in 1889 August he discovered four satellites of Brooks' comet, and that he has followed faint comets long after they had become invisible in other instruments, notably Brooks' comet of 1889, which was observed by him nearly a year longer than by any other observer ; and again, the comet discovered by himself in 1888, which he followed for over two years—the longest duration of visibility known. Such observations suggest the possibility of following some of the periodic comets all round their orbits, though it must be confessed that we are still far from the realisation of this hope.

Again, he has classified periodical comets by their visual appearance, so that on several occasions he has been able to tell a short-period comet at the first glimpse in the telescope.

In addition to the photographic discovery of new nebulæ, he has discovered many with the telescope ; he has made many observations of the surfaces of the planets *Mars*, *Jupiter*, *Saturn*, and of *Jupiter's* satellites (some of which are yet unpublished), particularly the very important one of the first satellite of *Jupiter*, showing the presence of dark polar caps and a white equatorial band, an observation of the utmost delicacy and importance, particularly in the light of the anomalous appearance attributed to this satellite.

Working with the 12-inch as well as the 36-inch telescope of the Lick Observatory, he has made a series of measurements of the diameters of the major planets and of their satellites, as well as of *Mercury* and *Venus*, and the first four Asteroids and many measurements of *Saturn's* rings. His measurements of double stars are not yet all published, but they include remeasurements of many of Burnham's difficult doubles. In addition he has discovered many others, as for instance, the most delicate double star connected with the trapezium of *Orion* and *β Capricorni*, which I have already mentioned.

I trust that these instances, not exhaustive, but tolerably representative, will be sufficient to show that the claims of Professor Barnard to the honour now conferred upon him are both strong, diverse in character, and very numerous.

It would, indeed, be a thankless task to attempt a complete account of his work, for the completeness would certainly be lost

in a very short time. Professor Barnard is in the presence of new opportunities which we all feel sure will add to his triumphs. He has left Mount Hamilton, but he has only exchanged one big telescope for another, and when the Yerkes refractor is ready, we may confidently expect news from Chicago of the kind with which he has made us familiar in the past.

The President then addressed the Foreign Secretary as follows :—Dr. Huggins :—I hope that it will not be necessary to ask you to forward this Medal to Professor Barnard, but that you will, within a very short time, be able to hand it to him. In doing so, I will ask you to express our great appreciation of his past work, and our very best wishes for his success in the future.

I have another pleasant duty to perform : to mention an award now made for the first time. This arises from a bequest by the late Mrs. Jackson-Gwilt, and consists, as the Fellows are no doubt aware, of a bronze medal and a gift of money.

Your Council have awarded this gift to Mr. Lewis Swift ; and I am sure that I need not say anything to you of Mr. Swift's astronomical labours, nor of the peculiar circumstances that will, I hope, make the gift doubly acceptable to him. In fact, as I have the opportunity of setting the precedent in this matter, I propose to refrain from giving an address ; for, though the Society has been accustomed to hear an address read in reference to the award of the Gold Medal, I think that there are reasons why the custom should not be followed in the case of this gift, and so I will only ask the Foreign Secretary to forward this medal and the gift to Mr. Swift, with the best hope of the Society that better times may come to him.

The meeting then proceeded to the election of the Officers and Council for the ensuing year, when the following Fellows were elected :

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